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EDITED BY CHAS. COOPER AND J. FOSTER PETREE.

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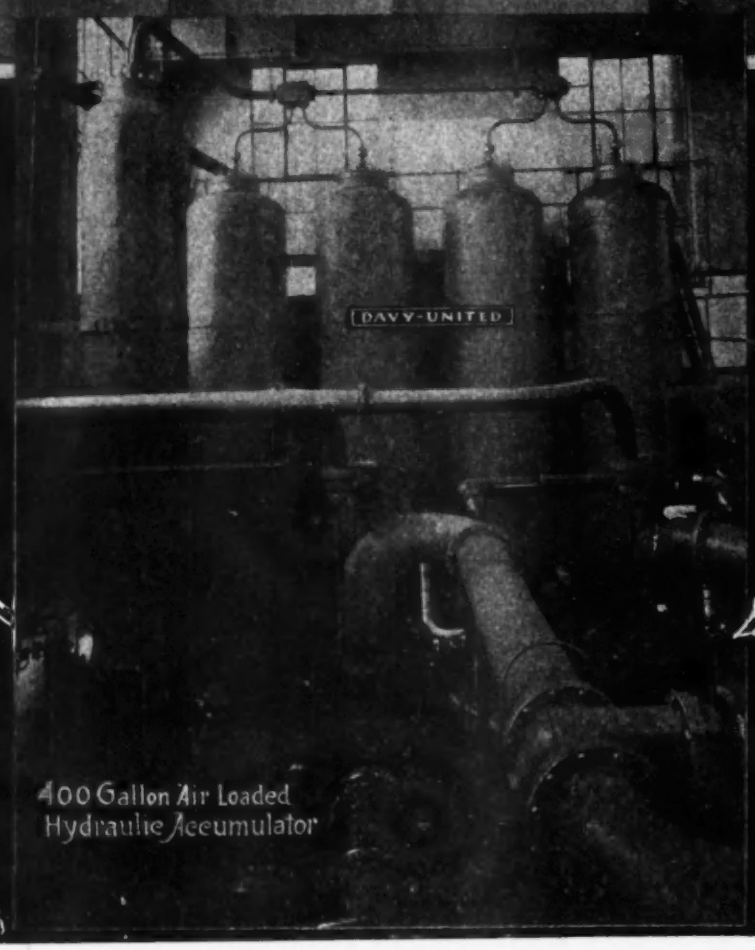

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THE FAILURE OF THE TACOMA NARROWS BRIDGE.

THE tendency of suspension bridges to oscillate vertically under the influence of lateral wind forces is inherent in the design, and is particularly noticeable in those of large span and, consequently, high length : width ratio. Primarily, the movements are due to side sway and local flexing of the suspension cables, though aerodynamic effects produced by the air currents passing above and below the deck are powerful contributory factors ; and the vibrations may, and frequently do, reach such amplitudes as to prevent traffic from using the bridge, even though the resultant stresses in the structure are still well within the customary margin of safety. Occasionally, however, they lead to structural damage. This happened in the case of the Menai Bridge in the storm of January 10, 1936, and it was this incident which brought to a head the proposals to modernise the Menai Bridge to meet present traffic requirements and led to the appointment of Sir Alexander Gibb and Partners, as consultants, to report upon the state of the bridge and to prepare the designs for the modifications, described in ENGINEERING just three years ago.* A second article, describing the actual reconstruction, appeared two years later.†

FIG. 1. SIDE SPAN OF BRIDGE AFTER COLLAPSE.

The most recent, and probably the most spectacular, instance of these forced oscillations in a suspension bridge was provided on November 7, 1940, when the Tacoma Narrows Bridge over Puget Sound, in the State of Washington, U.S.A., collapsed in a wind of little more than 40 miles an hour, after a prolonged period of such violent movement that, at times, the transverse section of the roadway was inclined at 45 deg. to the horizon. Eventually, the structure of the central span, 2,800 ft. in length, broke up completely, and fell in pieces into the water ; fortunately, without causing any personal injuries, the behaviour of the bridge having given ample warning for the public and the bridge engineers to retreat to a safe distance. For the following account of the failure of the bridge, based upon the report of an eye-witness, we are indebted to our American contemporary, *Engineering News-Record*.

The Tacoma Narrows bridge is the third longest suspension span in existence, its 2,800 ft. being exceeded only by the 4,200 ft. of the Golden Gate bridge at San Francisco, and 3,500 ft. of the George Washington bridge, New York. Both of these, however, are considerably wider, the former being designed to accommodate six lines of traffic and the latter, twelve ; whereas the Tacoma Narrows bridge has only two traffic lanes and two sidewalks. It was constructed between October, 1938, and July, 1940, by the Washington Toll Bridge Authority to a design by Mr. Leon S. Moissieff, consulting engineer, of New York, which was selected by a committee of consultants presided over by Mr. L. V. Murrow, director of the Washington State Highway Department and chief engineer of the Bridge Authority. The contract was entrusted jointly to the Pacific Bridge Company, the General Construction Company, and the Columbia Construction Company, and the total cost was some 6,400,000 dols. The superstructure was fabricated and erected by the Bethlehem Steel Company, and the wire spans and vertical suspenders were made by Messrs. John A. Roebling Sons Company. The two towers from which the cables were suspended are 425 ft. high. The depth of the stiffening girders of the roadway was 8 ft. They were constructed with $\frac{1}{2}$-in. web plates, stiffened by three longitudinal Z-bars on the inside of the web, and vertical channel stiffeners (which can be seen in the illustrations) on the outside.

From the outset, the bridge exhibited a disturbing tendency to oscillate. This tendency had been observed in the earlier Whitestone bridge, at New York, which is generally similar in type ; but there the movement amounted to a few inches only, whereas, in the Tacoma Narrows bridge, the vertical waves reached an amplitude of as much as 50 in. Various corrective measures were taken, and experiments were made with scale models by Professor E. K. Timby, at Princeton University, for the Whitestone bridge, and by Professor F. B. Farquharson, at the University of Washington, Seattle, for Tacoma Narrows. The models of the latter bridge, to a scale of 1/100, has an overall length of 54 ft., and is fitted with a series of electromagnets, which apply horizontal and vertical forces to simulate the effect of wind pressures. It was found that the behaviour of the actual bridge could be reproduced with great accuracy by these means, and the effect of the different corrective devices could thus be tested.

In the case of the Whitestone bridge, short inclined rope ties were inserted between the midpoints of the main cables and the top flanges of the stiffening girders. These restrained the deck from moving longitudinally with respect to the cables. The longitudinal movement was also damped by friction brakes, fitted at the points where the deck was connected to the towers. At Tacoma Narrows, however, a different method was tried, after being tested on the model, a point on each side span being tied to the ground below by means of $1\frac{1}{16}$-in. cables extending from the deck of the side spans to anchors, consisting of 50-cub. yd. concrete blocks, placed 300 ft. out from the anchorages. It is reported that these ropes were broken about a month before the actual collapse, by a wind of moderate force. Diagonal ties from the tops of the towers to the stiffening girders were considered, but these were not tried on the bridge itself. It may be mentioned that the tendency to oscillate was observed even before the bridge was completed ; and measurements made after its completion had shown that the bridge deck rose and fell over a maximum range of some 2 ft. 8 in., with very little side sway, although it was not supposed, at the time, that the safety of the structure was affected.

Further work was undertaken with the scale model, and with smaller models, which were tested in a wind tunnel, to determine whether the form of the stiffening girder was a contributory cause of the oscillation ; and the effect was tried of various forms of streamlined facing along the sides of the girders. Proper streamlining, it was found, almost completely cured the trouble, but the application of these experimental results to the actual bridge had not been possible at the time of the failure. Prior to November 7, the vertical waves (which were readily observable from the shore, and had been recorded by cinematograph) had occurred on both sides simultaneously and caused no damage, even at the maximum amplitude of 50 in. Ten different wave periods had been observed on the model at Washington University. On the bridge itself, the periodicity most frequently noticed was one of 12 seconds, corresponding with that of the towers. It had been noted, too, that the least vertical movement occurred at mid-span. Presumably, it was here that the maximum flexure took place ; an assumption borne out by the statements of several witnesses, which agreed in identifying this point as the one where the structure failed first.

The process of failure continued long enough for a very complete photographic record to be obtained of the behaviour of the span, and this includes a number of cinema films which should provide valuable evidence. Support for the theory that the stiffening girders were the first to fail is afforded by one photograph, which shows a definite misalignment of these girders at mid-span, when the concrete roadway was still intact. It is suggested that the misalignment may have been the result of a shear rupture. Another picture, taken soon after the first portions of the concrete fell out, showed a pair of diagonals, forming part of the lateral system of bracing, hanging loose below the floor.

Professor F. B. Farquharson, of the University of Washington—who, as mentioned above, directed the model experiments and, therefore, was familiar with the peculiarities of the bridge—was on the main span, at the time of the collapse, taking motion pictures of the abnormal waving and twisting. He reported that, although winds of greater velocity had been experienced previously without damage resulting, the 42-m.p.h. wind that was blowing on November 7 caused a vertical wave motion that developed a phase difference between the two side girders of the bridge. This gave the

* See ENGINEERING, vol. 144, page 651 (1937).
† See ENGINEERING, vol. 148, page 655 (1939).

FAILURE OF THE TACOMA NARROWS BRIDGE.

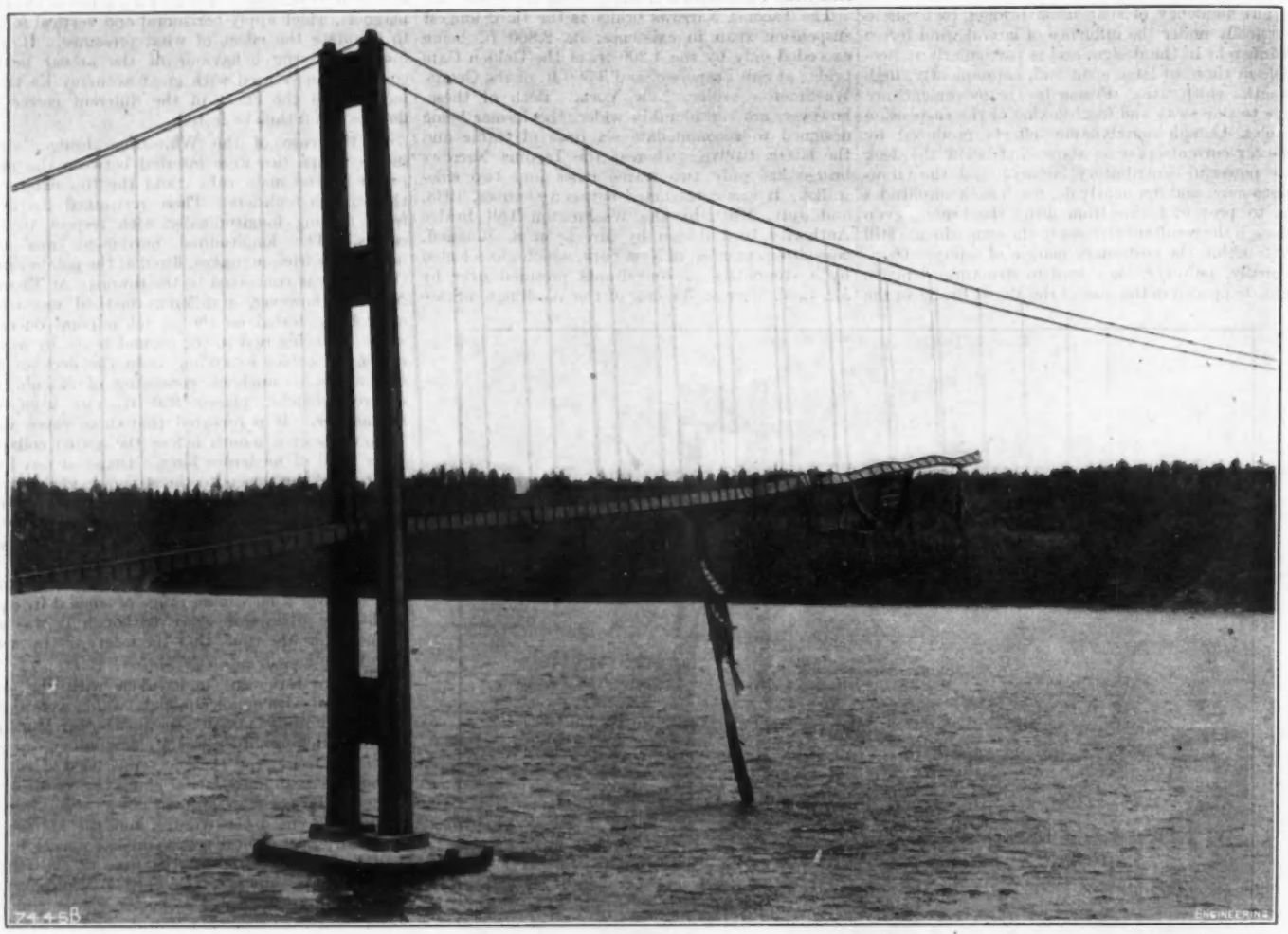

Fig. 2. Centre Span Falling.

deck a cumulative rocking motion from side to side, and Professor Farquharson reported that it tilted in each direction to an angle exceeding 45 deg. The edges of the deck moved up and down over a vertical range of some 28 ft., and, at times, the acceleration in its movement was greater than that due to gravity. As stated, failure apparently began at mid-span with the buckling of the stiffening girders, though it is possible that the lateral bracing parted first. As the violent whipping continued, many of the vertical suspension ropes were broken, while sections of the flooring fell out successively, several hundred feet at a time, until only short lengths of the roadway remained, projecting from the towers.

Although the report given in the *Engineering News-Record* states that the additional anchoring ropes fitted to the side spans had parted some weeks before the final collapse of the bridge, it appears that, either the broken ropes had been replaced or the breakage had not extended to all of them; for it seems that some were in position on November 7, and it was due to their presence that the wave movements in the main span were not transmitted to the 1,100-ft. side spans, a circumstance which probably saved the two towers, each 425 ft. in height, from earlier damage. When the main span collapsed, however, the removal of the load represented by its weight allowed the side spans to sag some 30 ft., as shown in Fig. 1, on page 481, buckling the stiffening girders and deforming the steel framework supporting the roadway. The unbalanced pull of the cables carrying the side spans bent the towers back 12 ft. towards the banks, buckling some of the plates and angles of the tower steelwork, more particularly at their bases on the piers, where the plate thicknesses are $\frac{1}{2}$ in. to $\frac{3}{4}$ in. The piers themselves are reported to be undamaged, and it is stated that the cables show no evidence of having moved in their saddles in spite of the violent jerking to which they were subjected.

The remaining three illustrations, namely, Fig. 2, above, and Figs. 3 and 4, on page 490, show the bridge actually in process of collapse. Fig. 2 shows the broken centre span, with the end of one of the stiffening girders still suspended from the cables, and a portion of the shattered framework of the roadway hanging down into the water. Fig. 3 was taken a few minutes before the girders broke and gives a good impression of the extremely violent waving and twisting movements which preceded their failure. In Fig. 4, a 600-ft. length of the roadway is seen falling into the waters of Puget Sound, apparently having turned over completely in tearing itself away from the remainder of the suspended structure. Towards the top right-hand corner of this illustration will be noticed an abandoned motor-car, trapped on the bridge by the rapidly-increasing oscillations.

Only about a month before the failure of the bridge, a model of a section of the floor system, one-twentieth full size, was tested in the wind tunnel at the University of Washington, the conclusion being reached that the cause of the vertical waves in the main span was aerodynamic instability. The behaviour of the span immediately before the collapse is stated to support this view. A remedy had been devised and successfully applied to the model, consisting of the addition of a deflector vane which so altered the aerodynamic characteristics of the section as to prevent the continual reversal of the vertical components of the wind forces. These forces, unless checked, had a cumulative effect on the wave motion, until such a mass was set in motion that its destructive energy was irresistible. A contract for the equipment of the bridge with this corrective deflector was actually in process of negotiation when the bridge failed.

We understand that the intention of the Washington Toll Bridge Authority is to reconstruct the Tacoma Narrows bridge, using the present towers and cables if, on completion of the examination, which is now in progress, their condition is found to justify it. The flooring of the side spans is being removed to facilitate the examination of the steelwork and to lighten the unbalanced load on the towers, and the final decision on whether the towers and cables will have to be taken down awaits the completion of this work and the subsequent detailed inspection. It may be presumed that, in any case, the reconstructed bridge will not differ greatly in proportions from the original structure, as the foundation conditions necessitate a long centre span. The unusual proportions represented by the length : width ratio of 72 to 1 may, perhaps, be modified, though the anticipated traffic does not justify the provision of more than two lanes if the undertaking is to be financially self-supporting.

Railway Bridge Over River Chenab, India.—The re-girdering of the Shershah Bridge over the Chenab River, near Mooltan, on the North Western Railway, has been decided upon by the Indian Railway Board. The bridge, which at present comprises 17 through-type spans, each 200 ft. long, carries a single broad-gauge track and a roadway on the same deck. The new spans will carry the railway track on a lower deck and an 18-ft. wide carriageway on upper booms.

LITERATURE.

The High-Speed Compression-Ignition Engine. By C. B. DICKSEE, M.I.Mech.E., M.I.A.E. London and Glasgow: Blackie and Son, Limited. [Price 16*s.* net.]

WHEN this book arrived for review, a cursory glance through the earlier pages induced some initial surprise that the author should have begun with what seemed to be yet another thesis on thermodynamics, the laws of gases, cycles of operation and chemistry of combustion—subjects which writers of text-books on the internal-combustion engine have dealt with *ad nauseam*, and about which it would seem that little remained to be written; but, knowing something of Mr. Dicksee, we expected that closer examination would elucidate this apparent mystery, and so it proved. Scientific data are here stated and commented upon by a man who is practically acquainted with the performance of actual engines, and whose experience has been second to none. In these early chapters, he gives many important lessons upon the impracticability of obtaining all that theory would indicate, and discusses the reasons in a manner which, so far as we are aware, has never before been so definitely expressed.

With no intention to discount this compliment, it is permissible, perhaps, to criticise one or two of Mr. Dicksee's remarks. In the preface it is stated that, "although workers on the high-speed engine have not been able to draw upon the experience gained with the low-speed engine, the converse is by no means true." A little earlier in this preface the following sentence also appears: "The high-speed engine is not the offspring of the heavy slow-speed engine and in actual fact owes it little beyond the incentive to obtain for the fast-running engine the improved economy obtained with the large engine when using a high ratio of expansion." These sentences carry no conviction of their fundamental truth. Surely it could be accepted as a fact that, if the slow-speed engine had not shown that high efficiencies were obtainable, the high-speed compression-ignition engine would not have had the ground work upon which its rapid development was so successfully obtained. Admittedly, high speeds and small cylinder volumes necessitated a considerable amount of adaptation, but this is a different matter. The high-speed compression-ignition engine had, perforce, to compete with the very highly-developed petrol engine, and to show to greater advantage from a commercial point of view. This entailed conditions of higher stress than usually exist in the low-speed engine and certainly brought about a new batch of problems, but it is somewhat stretching the truth to say that low-speed designs owe more to the high-speed engines than vice versa, as the sentences quoted above imply. Each has its own problems, and what interests the designer of high-speed engines does not necessarily have the same claim upon the consideration of his brother engineer, whose chief concern is probably with other matters more or less directly consequent upon the dimensional differences. In the first chapter, reference is made to "the true Diesel cycle," while later on it is stated (on pages 10, 14, 18 and 105) that the constant-pressure cycle, as applied to actual engines, is "commonly called the Diesel cycle." The author's apparent discrimination when using the word "true" is not set out as clearly as it might have been.

It is very gratifying to find that, in various parts of the book, the author stresses that, hitherto, too much attention has been given to the fuel consumption of internal-combustion engines, and not enough to air consumption. Engineers who have many years of experience will welcome this presentation of a fact that is not so widely accepted as it should be. Probably, as in many other instances, nomenclature is to blame and because we have talked of petrol engines, paraffin engines, gas engines, oil engines, and so on, we have been oblivious of the fact that hydrocarbon fuels, whether in liquid or gaseous form, merely decide how fuel containing the heat units convertible into power should be supplied. Mr. Dicksee makes it abundantly clear that the engine which utilises the larger proportion of the air present in the cylinder at each charge is the most efficient. It can be appreciated, therefore, that pressure-charged cylinders are justified—a point upon which many engine-users still appear to be dubious—because the greater amount of air present per unit of cylinder volume will deal with a larger amount of fuel per charge, resulting in more power per impulse without loss of combustion efficiency. In the case of the high-speed engine, the cost, size and additional resistances of the pressure-charging unit decide whether or not it is really advantageous.

On this question of air supply many novel points are made by Mr. Dicksee, resulting from special experiments which he has carried out in the course of his work with The Associated Equipment Company, at Southall, and his readers will join with him in expressing thanks to the management of that firm for so broadmindedly giving permission for such work to be made known outside their own experimental department, results which have been obtained at considerable cost and primarily for their own commercial advantage. The author emphasises, in a definite and clear manner, the fact that the efficiency of the cycle upon which internal-combustion engines operate must decrease as the maximum temperature increases, and as the period of heat reception is increased. The point is important, but is often overlooked by other writers with professorial rather than practical qualifications.

The first six chapters deal with the principal considerations which accord theory with practice. The remaining four chapters show, from the author's experiments and those of other specialists, how to obtain the best results from various practicable methods of creating air movement within cylinders, different conformations of combustion chambers, and different types of fuel-injection devices. A concise résumé of practical results closes the volume. Some idea of the relative importance which seems to be implied for each of these chapters may be gained from the relative number of their pages. On this basis, fuel injection takes first place; air movement, second; and types of combustion chamber, last. The final chapter, including remarks upon future development, is deserving of close study; it is probably the best in the book.

The combination of recent research reports emanating from workers in Great Britain and in the United States with Mr. Dicksee's co-ordinating remarks, places this book far ahead of any hitherto published on the same subject. Many engineers will, in consequence, more fully appreciate the ingenuity that has been displayed in these researches and will begin to realise the vast amount of money and time that has been spent in this direction, and to such good purpose. In his preface, Mr. Dicksee rightly states that, in the development of the high-speed compression-ignition engine, the engineer has taken full advantage of the opportunity to accumulate mass experience at a rapid rate; due, mainly, as he says, to the greater number of engines of the type always in service or in progress as compared with the numbers of slow-speed engines. This is certainly true, but there has been yet another reason, namely, that of the facilities provided during recent years for the presentation and discussion of papers before a multiplicity of engineering institutions, to say nothing of the technical Press. Mr. Dicksee, indeed, makes acknowledgment to no fewer than five institutions for permission to reproduce diagrams and quotations from their *Proceedings*. By writing this book, he has placed internal-combustion engineers greatly in his debt. To students in particular, it will be invaluable.

A New Dictionary of Chemistry. Edited by DR STEPHEN MIALL. London: Longmans, Green and Company, Limited. [Price 42*s.* net.]

DICTIONARIES and similar works of reference are always difficult to review, because so much of their potential value depends on the needs and the equipment of the individual user; but the task is simplified when the compiler indicates clearly, as Dr. Miall has done in the present instance, the particular classes of inquirers for whom the work is intended. Unfortunately, although there is much that is meritorious in its format and in the style and matter of many of the entries, the *New Dictionary of Chemistry* displays so many inequalities as hardly to conform to its comprehensive specification. Chemistry is one of the most widely diffused of sciences, and the book ranges over chemical engineering, pharmacology, bio-chemistry, crystallography and even biography in the endeavour, as the introduction claims, to be useful to "doctors, druggists, physiologists, chemical manufacturers, works managers, chemical engineers, patent agents, lawyers, journalists," and many other practitioners, whose requirements and chemical knowledge are as varied as their occupations, and represent an enormous field to be covered in a mere 575 pages.

It becomes important, therefore, to observe how the available space has been distributed. In general, there are entries for most of the common chemicals, elements and compounds, and many organic compounds and chemical engineering terms, as well as for plastic materials, refractories, dye-stuffs and colloids. The notes on carbohydrates, enzymes and alkaloids are particularly numerous and are well done. There is even a table of stable isotopes, and a table of physical constants of some organic compounds; though the latter duplicates certain matter already given elsewhere in the text. Cross-referencing, however, is not on a generous scale, and it is possible to miss such entries as those of turpentine, peppermint and other volatile oils, because they are given as "oil of . . ." In some cases, space is expended unnecessarily on trite scientific information which must surely be known to anyone who would consult such a book at all, while the explanation of, perhaps, some interesting application is omitted. Perfumery and cosmetics—nowadays an important branch of chemical manufacture—are rather neglected, as are certain important vegetable oils. A few omissions which have been noticed are wormwood, millilitre, siccative, dryer, absolutes, lavender oil, resin, carnauba, ambergris, gum tragacanth and gum arabic. On the other hand, no opportunity is overlooked of giving the effects of drugs on the human body; information, the inclusion of which is difficult to justify, since no medical man would go to a work of this kind for such specialised knowledge, while most other potential users of the book would be unlikely to require it.

Turning to the biographical notes: if the questionable policy of including those of living persons be accepted, it is surprising to observe some of the omissions, and the paucity of certain of the entries. A critical reader might well wonder why some of the names are mentioned at all, when the details given are so little suggestive of eminence. Summarising the impressions left by a fairly close examination of the book, it may be said that many of the entries are admirably done; but, bearing in mind its intended public, it contains too much specialised organic chemistry, and too much biographical and purely medical matter, while there is not enough about common things of the kinds cited above. Any revision should certainly aim at including many more, and more detailed, references on the great and still growing subject of chemical engineering.

THE LATE MR. L. BURBIDGE.—We note with regret the sudden death of Mr. Leonard Burbidge, which occurred on December 1. Mr. Burbidge was London manager of Messrs. Blackstone and Company, Limited, Stamford. Before occupying this position he spent several years in the United States as manager of the technical sales staff of Messrs. Peet and Powers, Incorporated, New York.

SALVAGE ON THE GREAT WESTERN RAILWAY.—As the result of recent investigations into salvage problems on the Great Western Railway, measures have been taken to ensure the maximum recovery of all scrap materials, so as to make them available for the national war effort. Dumping grounds are being provided at suitable points at the larger stations, docks, depots and offices, giving separate accommodation for iron and steel, brass, etc.; sacking and rags; and tins and miscellaneous scrap. At small stations, a mixed dump only has been established. To clear the accumulation of scrap a number of special salvage vans is being provided to make regular calls at all the principal stations, and proceed, when loaded, to the nearest stores depot—of which there are five—for re-sorting and disposal of the contents. Each van is fitted with four separate bins suitably lettered to receive a particular class of salvage.

VIBRATION PATTERNS OF PROPELLER BLADES.*

By DR. G. S. BAKER, O.B.E.

EARLY in 1936, at the instigation of the Laboratory, the "Singing Propeller Committee" of the Institution of Naval Architects included amongst other recommendations in their report a proposed research on "the manner in which typical blades vibrate and the effect on vibration characteristics of changes in shape, thickness, etc." The report was never printed for general circulation, but this particular research was approved by the Advisory Committee of the William Froude Laboratory some two years later, and this paper contains the results obtained so far. One of the difficulties involved in the discussion of vibrating propellers has been the absence of any experimental or general knowledge of the modes of vibration of propeller blades. A few experiments were made by Mr. Harry Hunter, using a shaped flat uniform-thickness plate which was set in motion by "bowing" it. This gave some patterns, but not frequencies. Tests with a single propeller blade having a flat driving surface have recently been published by Messrs. Kerr, Shannon and Arnold. As before, the blade was held in a vice and vibrated by bowing the edge. Frequencies are given with these diagrams, being measured by tuning fork and mono-chord. The method adopted to vibrate the blades in the present experiments was devised in conjunction with the Physics Department of the National Physical Laboratory, the apparatus being made and the experiments being carried out by Mr. E. J. Evans of that department.

The model propellers were one foot in diameter, made with two blades on a heavy boss 2·25 in. in diameter and 3·2 in. in length. The propeller was rigidly secured to a massive iron plate by a 1·25-in. diameter bolt and nut. The propeller blades were made flat on the driving face, which was in a horizontal plane when secured to the base plate. The method of exciting vibration of the blades was by an electro-magnet with the pole tips just above the blade surface. The pole tips were about $\frac{1}{4}$ in. square and $\frac{1}{4}$ in. apart, so that the exciting force was applied over a small area of the blade. The magnet could be moved horizontally over the whole surface of one blade. It was supplied with alternating current from a beat tone oscillator and amplifier. The frequency could be varied continuously over a range of about 50 cycles to 11,000 cycles per second. In addition to the alternating current, the magnet was supplied with direct current through a separate pair of coils. In this way, the magnet produced an alternating field of known frequency, superimposed on a direct field. To find the resonant frequencies of the propeller, fine sand was sprinkled on the upper surface of the blades, and the exciting current was slowly varied through a given and known range of frequency. The resonance frequencies were detected by the loudness of the note emitted by the propeller, and by the sand on the blades taking a definite pattern—the sand usually moving towards the nodal regions. The magnet was traversed about the blade in the tip region until the clearest diagram had been obtained on the blade under the magnet and the most intense note had been found. The frequency was then noted, the magnet removed, its position marked by a black dot, and a photograph of the sand pattern taken. The experiment was repeated with slight variation in frequency to obtain the best definition on the other blade and a photograph again taken. A wide selection of these photographs are used to illustrate the paper, and are reproduced on Plates XXXIII and XXXIV.

The propellers were made in cast iron, the rough castings being supplied by the North Eastern Marine Engineering Company (1938), Limited. Seven have been tested in this series. Their general characteristics are given in Table I, on this page, and details of two typical blades in Figs. 1 to 3, herewith. Three of them (E.7, 3 and 6) had blades with symmetrical outline. Four had various degrees of curvature to the leading edge, the trailing edge and tip being skewed back for this purpose. The outlines of the blades can be seen from the sand photographs given in the paper. Three (E.3, 7 and 4) had circular back sections to the blades, two (E.5 and 6) had aerofoil section of A 0·33 type throughout, two (E.2 and 8) had A 0·35 type of section at the root changing to A 0·5 and 0·45 at the tip. The thickness tapered uniformly from root to tip and was the same in all but E.7, which had a curved thickness line (see Fig. 2), but was otherwise the same as E.3. Broadly, it may be said that screw E.3 had blades of the type in general use some 20 years ago—slightly wide tipped with circular back sections. At the other end of the Table is a model (E.8) with a normal modern type of blade, of the same blade area and thickness.

* Paper read before the North-East Coast Institution of Engineers and Shipbuilders at Newcastle-upon-Tyne, on Friday, November 15, 1940. Abridged.

VIBRATION PATTERNS OF PROPELLERS.

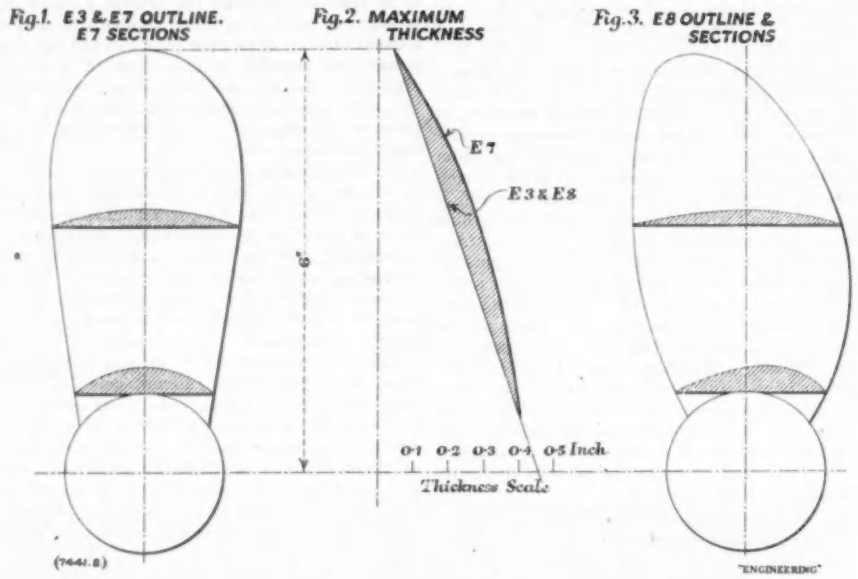

TABLE I.—DIMENSIONS AND CHARACTERISTICS OF MODEL VIBRATING (FLAT BLADE) PROPELLERS.

Diameter, 1·0 ft.; diameter of boss, 0·187 ft.; number of blades, two.

	Symmetrical Outline.			Skewed-Back Blades.			
Blades No.—E	3.	7.	6.	4.	5.	2.	8.
Characteristic.	Normal Circular* Back.	3 with Thickened Blade.	3 with Aerofoil Sections.	3 with Skew Back.	4 with Aerofoil Sections. / 6 with Skewback.	Heavy Skew Narrow Tip.	Moderate Skew Modern Type.
Chord / D							
root ..	0·165	0·165	0·165	0·165	0·165	0·178	0·178
0·6 radius ..	0·228	0·228	0·228	0·234	0·234	0·228	0·238
0·9 radius ..	0·180	0·180	0·180	0·171	0·171	0·137	0·137
Diameter for maximum width / D	0·7	0·7	0·7	0·6	0·6	0·48	0·48
A value of back ..	0·5	0·5	0·33	0·5	0·33	0·35 root 0·5 tip	0·35 root 0·45 tip
Camber ratio							
root ..	0·192	0·192	0·192	0·192	0·192	0·178	0·178
0·6 radius ..	0·075	0·102	0·075	0·072	0·072	0·074	0·071
0·9 radius ..	0·037	0·055	0·037	0·037	0·038	0·049	0·049

* For 70 per cent. blade length from the tip to A 0·42 at blade root.

Since this work has been undertaken with a general idea of applying the results to the problem of the singing propeller, it was desirable to have some idea of the range of frequencies which need to be studied for this purpose. The noise (if any) made by a bronze propeller about 18 ft. in diameter, propelling a ship in smooth water, is either a low-pitched hum with beats in it proportional to the number of blades and of frequency varying from 200 cycles per second to a somewhat higher figure; or a grinding noise or grunt with a maximum once per revolution of propeller, the major tone of which may vary from 200 cycles to 300 cycles per second. Either or both of these may be present. When such a propeller in bronze is struck either in air or in water, the predominant note heard has a frequency lying between 180 cycles and 300 cycles per second.

There are two principal modes of vibration which need to be considered, namely (*a*) that in which the blade tip as a whole moves perpendicularly to the blade surface, which is referred to in this paper as flexural; and (*b*) that in which the blade twists from the boss about a more or less central line lying on its surface, referred to in this paper as torsional. Another form of vibration which appears on the blades when the frequency is raised above that of the primary modes, is a lateral flexural motion, *i.e.*, one in which the motion is vertical but essentially across the blade from edge to edge. This kind of vibration is listed by Kerr, Shannon and Arnold as "plate vibration" (*Proc. I.Mech.E.*, 1940), Harry Hunter (*Trans. N.E.C. Inst.*, 1936-37), and A. W. Davis (*Trans. I.E. & S.*, 1939) call it lateral vibration, and this seems to the author a more satisfactory name. It often occurs only at the tips, but a high frequency can be found on some blades when it spreads along the greater part of the blade. Eventually, at very high frequencies, we have a rippling of the edges about the central stiff part of the blade, giving nodal lines in a series of loops along each edge, none of them very well marked.

The following formulæ for the first two kinds of vibration have been obtained by Conn for a blade of parabolic outline and a straight thickness line from root to tip:—

	Flexural.	Torsional.
Fundamental	$0\cdot29\,\frac{t_r}{l^2}\sqrt{\frac{gE}{\rho}}$	$0\cdot99\,\frac{t_r}{b_r l}\sqrt{\frac{gN}{\rho}}$
Higher frequencies / Fundamental	1 : 2·61 : 4·9 : 8·0	1 : 1·57 : 2·13

where b_r and t_r are chord and thickness at the root, respectively; l = free length of blade, boss to tip; ρ = density of material = 0·3 for manganese bronze and 0·26 for cast iron, in lb. per cub. in.; E = Young's modulus of elasticity = 14×10^6 for manganese bronze and 14 to 23 $\times$ 10^6 for cast iron; N = modulus of rigidity = $4\cdot5 \times 10^6$ for manganese bronze and 5·5 to 8·0 $\times$ 10^6 for cast iron; and g = acceleration due to gravity = 32·2 $\times$ 12, all units being in lb. and inches.

These formulæ are for thin blades, and, with the thick roots of normal propeller blades, the frequencies with an actual blade would be somewhat higher. They hold good only for a blade of the particular outline chosen, but serve to show the factors on which frequency depends as size is varied. For similar screws

VIBRATION PATTERNS OF PROPELLER BLADES.

(*For Description, see Page* 484.)

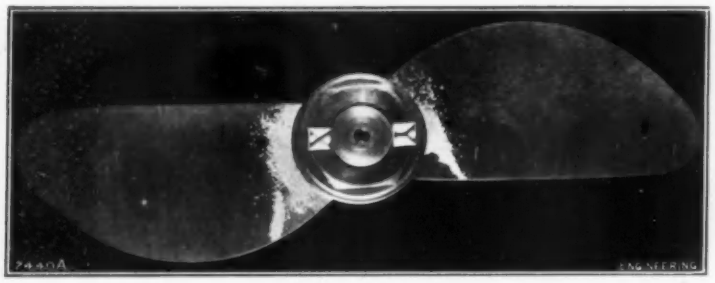

FIG. 4. E.2 AT 560 CYCLES PER SECOND.

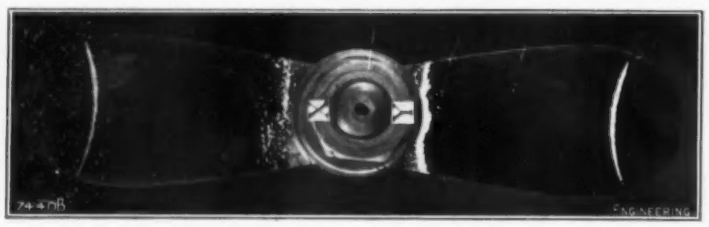

FIG. 5. E.6 AT 1,710 CYCLES PER SECOND.

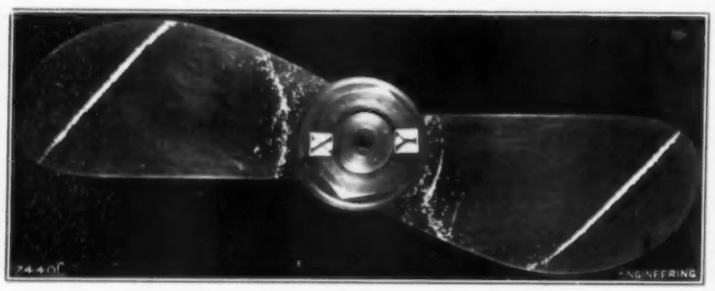

FIG. 6. E.5 AT 1,750 CYCLES PER SECOND.

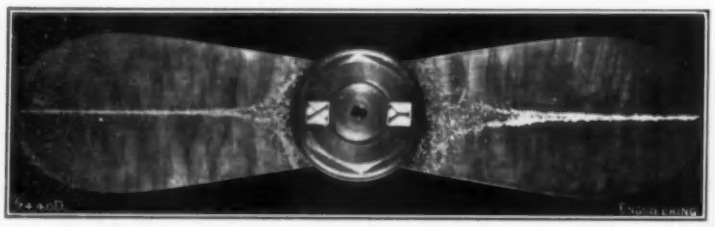

FIG. 7. E.3 AT 1,490 CYCLES PER SECOND.

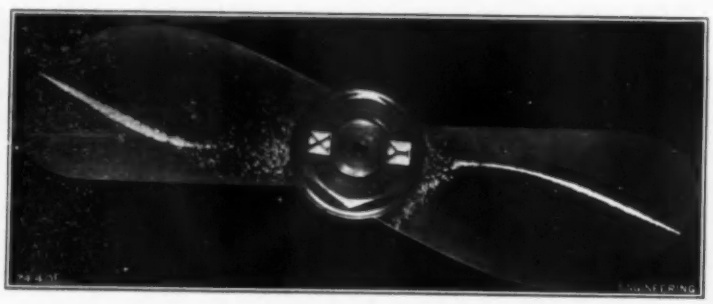

FIG. 8. E.4 AT 1,400 CYCLES PER SECOND.

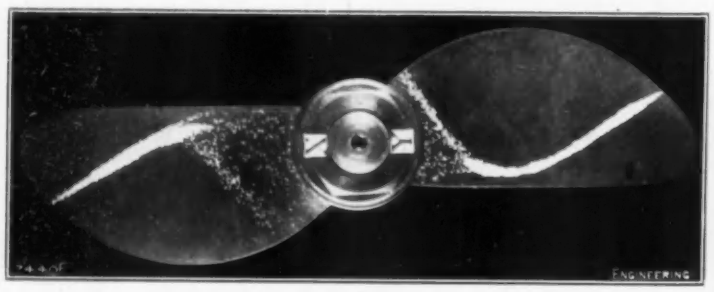

FIG. 9. E.2 AT 1,440 CYCLES PER SECOND.

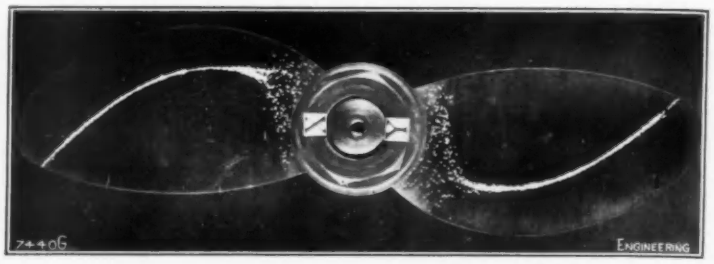

FIG. 10. E.8 AT 1 810 CYCLES PER SECOND.

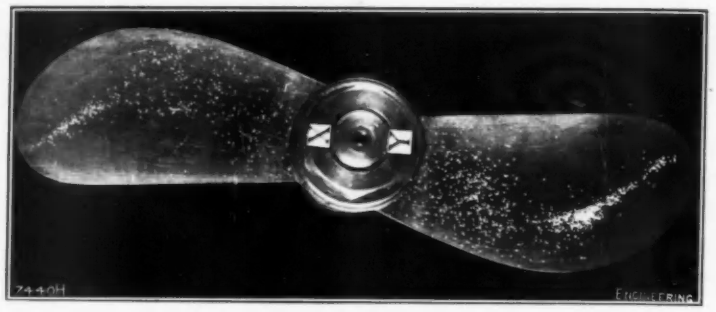

FIG. 11. E.4 AT 2,230 CYCLES PER SECOND.

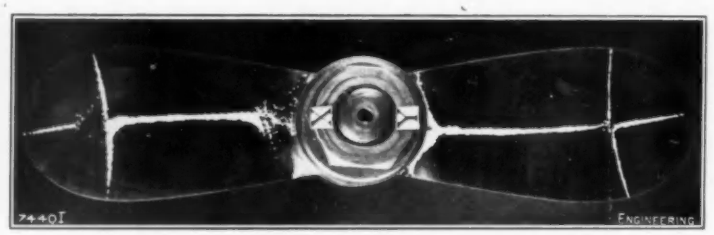

FIG. 12. E.6 AT 3,050 CYCLES PER SECOND.

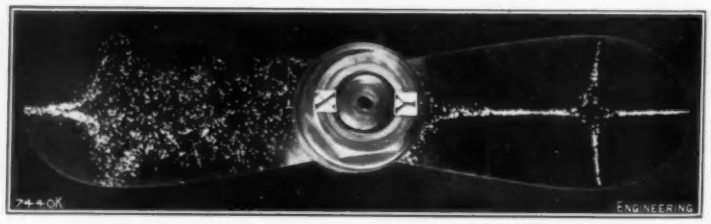

FIG. 13. E.7 AT 4,270 CYCLES PER SECOND.

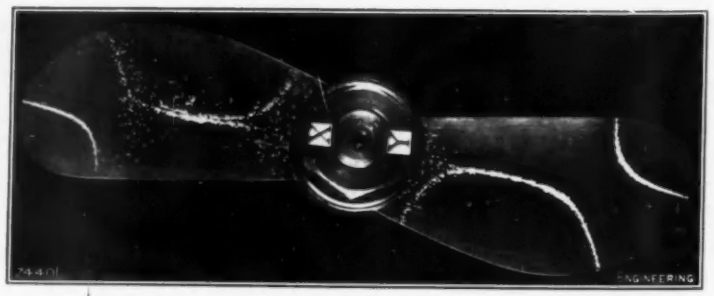

FIG. 14. E.4 AT 3,080 CYCLES PER SECOND.

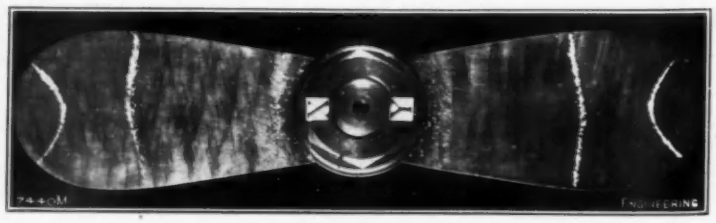

FIG. 15. E.3 AT 3,530 CYCLES PER SECOND.

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(*For Description, see Page* 484.)

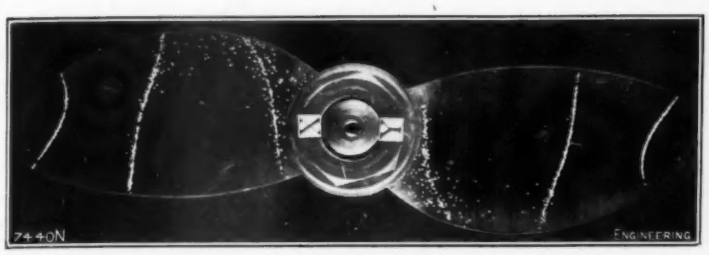

FIG. 16. E.8 AT 3,740 CYCLES PER SECOND.

FIG. 17. E.3 AT 5,040 CYCLES PER SECOND.

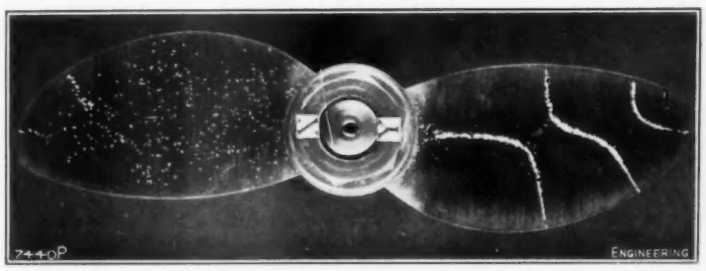

FIG. 18. E.8 AT 5,230 CYCLES PER SECOND.

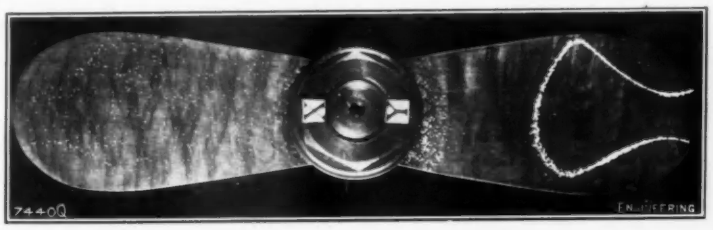

FIG. 19. E.3 AT 5,280 CYCLES PER SECOND.

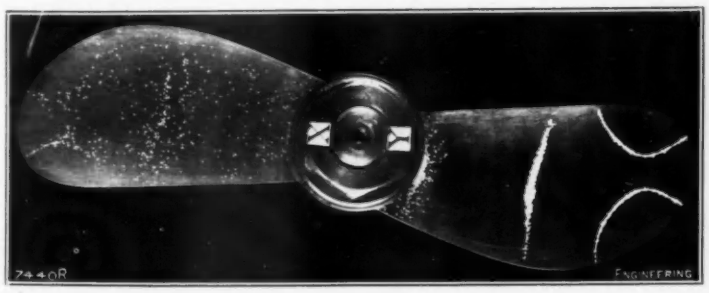

FIG. 20. E.4 AT 5,760 CYCLES PER SECOND.

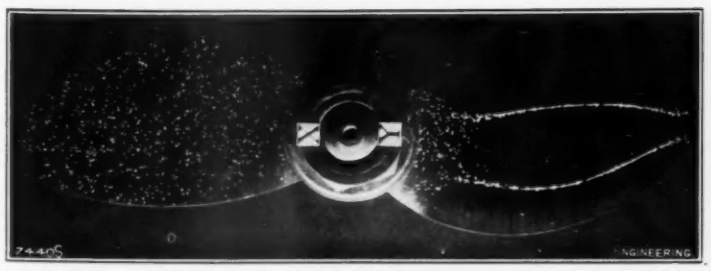

FIG. 21. E.8 AT 6,690 CYCLES PER SECOND.

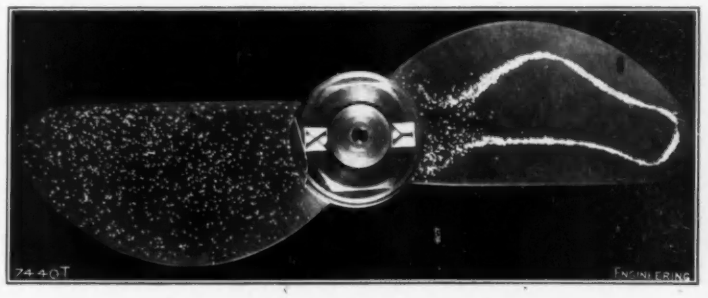

FIG. 22. E.2 AT 7,130 CYCLES PER SECOND.

FIG. 23. E.4 AT 6,270 CYCLES PER SECOND.

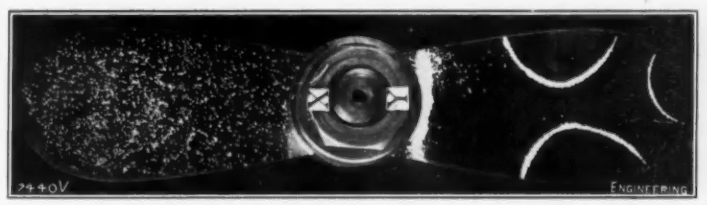

FIG. 24. E.6 AT 5,470 CYCLES PER SECOND.

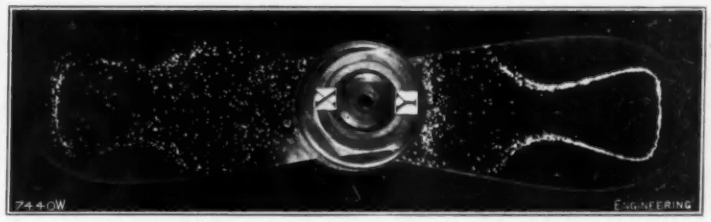

FIG. 25. E.7 AT 8,100 CYCLES PER SECOND.

FIG. 26. E.4 AT 10,300 CYCLES PER SECOND.

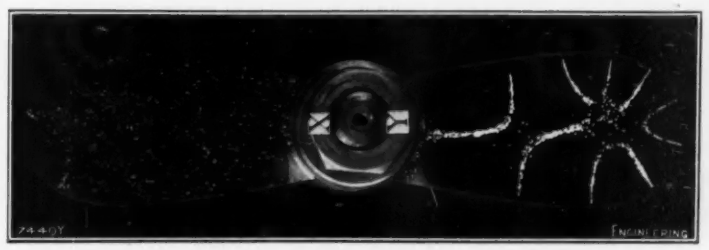

FIG. 27. E.6 AT 8,870 CYCLES PER SECOND.

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TABLE II.—FLEXURAL VIBRATION FREQUENCIES.

Cycles per second for 1·0 ft. diameter.

Screw	3	7*	6	4	5	2	8§
Primary	490 / 510	550 / 580	510 / 530	490 / 520	490 / 510	540 / 560	560 / 570
As figure :—	4	4	4	4	4	4	4
Second order	1,650 / 1,700	2,130 / 2,230	1,670 / 1,710	1,730 / 1,700	1,730 / 1,760	—	—
As figure :—	5	5	5	6	6	—	—
Third order	3,500 / 3,560	4,720	3,410† / 3,520	3,570 / 3,650	3,430 / 3,510	3,700‡ / 3,760‡	3,740 / 3,750
As figure :—	15	15	15	16	16	16	16
Fourth order	—	—	—	—	—	5,750 / 5,800	5,910 / 5,970
Second / primary	3·35	3·86	3·25	3·45	3·49	—	—
Third / primary	7·05	8·35	6·68	7·15	6·95	6·78	6·63
Fourth / primary	—	—	—	—	—	10·5	10·5
Essentially lateral vibration	5,930 / 5,940	8,050 / 8,100	5,470 / 5,660	6,200 / 6,270	5,760 / 5,930	7,030 / 7,130	6,660 / 6,690
As figure :—	24	25	24	23	23	22	21

* This propeller had blades 0·39 in. thick, clear of vice, 0·38 on the others. Its frequencies should be reduced about 2 per cent. to allow for this in comparison with the others.
† Poorly defined pattern.
‡ Actually mixed with some lateral vibration which distorts the pattern at the inner half.
§ The E value of this propeller was rather high.

TABLE III.—TORSIONAL AND MIXED RESONANCE.

Extreme Values of Cycles per Second, for both Blades Excited Directly or through Boss from the other Blade.

Screw	3	6	7	4	5	2	8
Primary torsional	1,450 / 1,490	1,480 / 1,500	1,800 / 1,840	1,400 / 1,430	1,370 / 1,400	1,440 / 1,460	1,630 / 1,670
Pattern of figure	7	7	7	8	8	9	9
Second form of torsional	2,230* / 2,250	2,390 / 2,400‡	Not obtained.	2,230 / 2,230	1,880§ / 2,200§	1,910 / 1,970	1,810 / 1,840
Pattern of figure	—	—	—	11	11	10	10
Cross pattern	3,100 / 3,160	3,030 / 3,050	4,270 / —	—	—	—	—
Pattern of figure	12	12	13	—	—	—	—
Torsion at root with flexing tip	—	—	—	3,030 / 3,080	2,850 / 2,990	2,920¶ / 3,020 and 3,700 / 3,750	3,310 / 3,340
Pattern of figure	—	—	—	14	14	14	14
Mixed torsional at root and flexural at tip	5,040‖ / 5,060	4,780 / 4,930	Not obtained	4,930 / 5,070	4,680 / 4,840	4,740 / 4,760	5,210 / 5,230
Pattern of figure	17	17	—	18	18	18	18
Mixed torsional and flexural	5,280 / 5,260	Not obtained	7,230 / 7,260	5,620 / 5,760	5,240 / 5,410	Not obtained	Not obtained
Pattern of figure	19	—	20	20	20	—	—

* Both these were very indistinct.
‡ Very indefinite.
§ Driving on different edges.
‖ The cross and radial flexural lines meet at the blade edges in this and form a central flapping disc.
¶ The lower frequency is as Fig. 14 ; the higher one has radial flexure down the trailing edge instead of leading edge, hence the inner nodal lines curve the other way.

of different diameters, both the torsional and flexural frequencies will vary inversely as the diameter. Hence, the troublesome range of 180 cycles to 300 cycles per second on an 18-ft. screw would be represented by 3,200 cycles to 5,400 cycles per second for the 1-ft. diameter model screws, if of the same metal in both cases. For smaller ship screws the range would be lower. It will be noted that change of metal from bronze to iron will alter the relative sequence of the torsional and flexural resonant frequencies, the torsional rising more than the flexural in the change ; but other differences between the two metals lie in the much greater internal damping of the cast iron, the relatively larger boss generally used with cast iron, and the greater thickness of blade which must be used with the latter for strength purposes. For the same ship, a cast-iron propeller will always have an upward movement in its frequencies compared with bronze, varying around 20 per cent. for flexural and 30 per cent. for torsional resonance.

Although the two blades of any propeller were made alike within the normal limits of error for model work, it was found that actually they had slightly different resonant periods. The extreme figures obtained for the two blades for any mode of vibration are given in the Tables. Careful checking of the blades showed that the errors in them could not account for the whole of these variations, and that some of it must arise from variations in the metal of the two blades. For all low frequencies, resonance was clearly defined for all the propellers, provided that the excitation point was over the outer part of the blade. With high frequencies, to get a well-defined pattern, the excitation had to be near the tips, and some very mixed modes of vibration were found, due to the superposition of a free oscillation of the blade tips upon the motion of the blades as a whole. With these mixed modes of vibration, the pattern and frequency varied to a small extent with the point of excitation, but the differences for a given type of motion were never large. As has been suggested, our main concern is with vibrations of frequency between 3,200 cycles and 5,500 cycles per second ; but, in surveying the results, it is simpler to take the low frequency first and to trace the variations as the frequency increases. In this way any effect of blade outline, sections, etc., is made clearer. This method has been followed in the following notes for frequencies up to about 5,500 cycles per second, above which only general conclusions have been attempted.

The lowest resonance occurs with the primary flexural, when the whole blade is bending about the root. A typical sand diagram is shown in Fig. 4, on Plate XXXIII. The resonance frequencies are given in Table II, herewith. These are generally around 500 cycles per second, except for E.2 and E.7, the former having a wider root and narrower tip, and the latter being thicker over the main part of the blade. There is a considerable gap between the above and the next resonant modes of vibration. Both the second order of the flexural and the primary torsional occur fairly closely together, within the range 1,400 cycles to 1,800 cycles per second. Typical diagrams of the second-order flexural are given in Fig. 5, on Plate XXXIII, for the symmetrical outline blades, and Fig. 6, on the same Plate, for unsymmetrical outline blades. The resonance frequencies for the various blades and the ratio of these to the primary frequencies are given in Table II. The clear transmission of vibration from one blade to the other across the boss will be specially noted. This second-order flexural could not be found on E.8. It is thought that this is due to its frequency coming very near the torsional and a lateral vibration resonance, and the blade vibrates in these modes in preference to the radial flexural movement.

The other resonance in this region is the primary torsional. For the blades with symmetrical outlines, this was clearly defined by a nodal line along the centre of the blade, as shown by Fig. 7. With unsymmetrical outline blades, there are two patterns of motion, one essentially torsional, with the nodal line extending from a point on the leading edge some distance off the tip, to a not very well defined position near the trailing edge at the root. Typical lines are shown in Figs. 8 and 9. The frequencies for this motion are very similar to those for the symmetrical blades, and presumably the motion is set up in the same way. Excitation along either edge near the tip would create this pattern, and with correct frequency movement of the point of excitation did not perceptibly change the pattern, but only varied the strength of the note emitted. In the second type of resonance, the nodal line tends to follow the centre of gravity of the cross-sections of the blades—or, put another way, follows the leading edge when this is bowed out as in some of these screws. The nodal line curves from the root to a point on the trailing edge well away from the tip. This is illustrated by Figs. 10 and 11, and the frequencies are given in Table III, on this page. The motion must be regarded as torsional near the root, but its relative high frequency and shape of the nodal line suggests that the vibration is influenced by a lateral flexural motion of the blade edge. This resonance is well marked on blades E.2 and E.8., but loses definition on E.4 and E.5, with their wider tips. On E.6, the position of the nodal line depended on the excitation point, the nodal line bending away from this point, and only a very indefinite line was producible on the unexcited blade. It will be noted that the nodal line near the tip for this motion is very similar in position and angle to that for the second-order flexural motion of the same blades.

The next resonance occurs at about 3,000 cycles per second. For the symmetrical-outline blades, the nodal lines take the form of a cross, and appear to be a second-order torsional vibration. Typical patterns are shown in Figs. 12 and 13, and frequencies are given in Table III. With the unsymmetrical-outline blades, resonance occurs at practically the same frequency, but the pattern of the motion is distorted, as shown by Fig. 14, from torsional over the inner part of the blade to mixed motion at the tip. The unexcited blade always showed the motion at the blade tip, but not always at the root. (See Fig. 13.)

This was followed by resonance, due to third-order flexural vibration, which occurred at and about 3,500 cycles per second. The type of motion is shown

by Fig. 15 for symmetrical outline blades and by Fig. 16, Plate XXXIV, for unsymmetrical outlines. The frequencies are given in Table II. This motion, although clearly defined on all the other blades, could not be obtained with E.2. With this, the nodal line across the centre of the blade, which was merely bent on E.4, E.5 and E.8, curves round to the boss, indicating some torsional motion at the root set up by the flexural motion at tip. The motion is like that shown by Fig. 10 with a flexing tip motion added. With these high frequencies, when one portion of the blade is moving differently from another, any want of balance in outline is almost bound to set up torsional motion, which disturbs the pattern and gives a frequency different from that which would have been obtained had the blade been symmetrical. It is possible, too, to find two resonances obviously due to mixed motion, in one of which the torsional has its major effect, and in the other the flexural motion of the tip has its greatest effect.

Such mixtures occur in the frequency range 4,700 cycles to 5,300 cycles per second, and their frequencies are tabulated in Table III. One set is made up of either lateral or radial flexure of the tip, combined with torsional motion at the root (Figs. 17 and 18), and the other of lateral flexure at the tips, combined with radial flexure at the root (Figs. 19 and 20). In Fig. 19, these nodal lines of the lateral flexural motion meet the cross nodal line near the blade centre, to form a central flapping disc. These mixtures could not be obtained on all the propellers, and it will be noticed that propeller E.7, with its thick blades, shows one variety only, and that at a very high frequency. The determining factor in the type of motion appears to be not only the frequency, but the point of excitation and shape of blade tip. Transmission of the motion across the boss to the other blade was very poor, only the tip of the unexcited blade showing a pattern, except with E.2, which again showed a complete pattern on both blades.

This takes us to the highest range of frequency which need be considered, but one other type of resonance is mentioned, as this might acquire importance in wide blades. In this, the predominant motion is of lateral flexural form with two nodal lines along the length of blade. It is shown fairly clearly in Fig. 21, and mixed with subsidiary motion in Figs. 22, 23, 24 and 25. The frequencies are given in Table II, and, for these screws, are generally higher than would produce singing on a normal ship screw. As a matter of record, disc motion of the blade tip (*i.e.*, the whole edge of the tip flexing as if it were part of a disc), as discussed by Dr. Davis, was found on only two propellers, and then at too high a frequency to have any effect on the singing problem. These cases are shown by Figs. 22 and 25. The more common form of tip motion is that shown by Fig. 20, which is fairly stable, and is met again on all the propellers except E.2, in the region of 8,000 cycles per second, and except for E.7, which develops it at 10,200 cycles per second. At this higher frequency, there is simply one more flexural nodal line. At still higher frequencies, the nodal lines develop a pattern like scalloping all down both edges—none very clear except at the edges. Two such patterns are shown in Figs. 26 and 27.

(*To be continued.*)

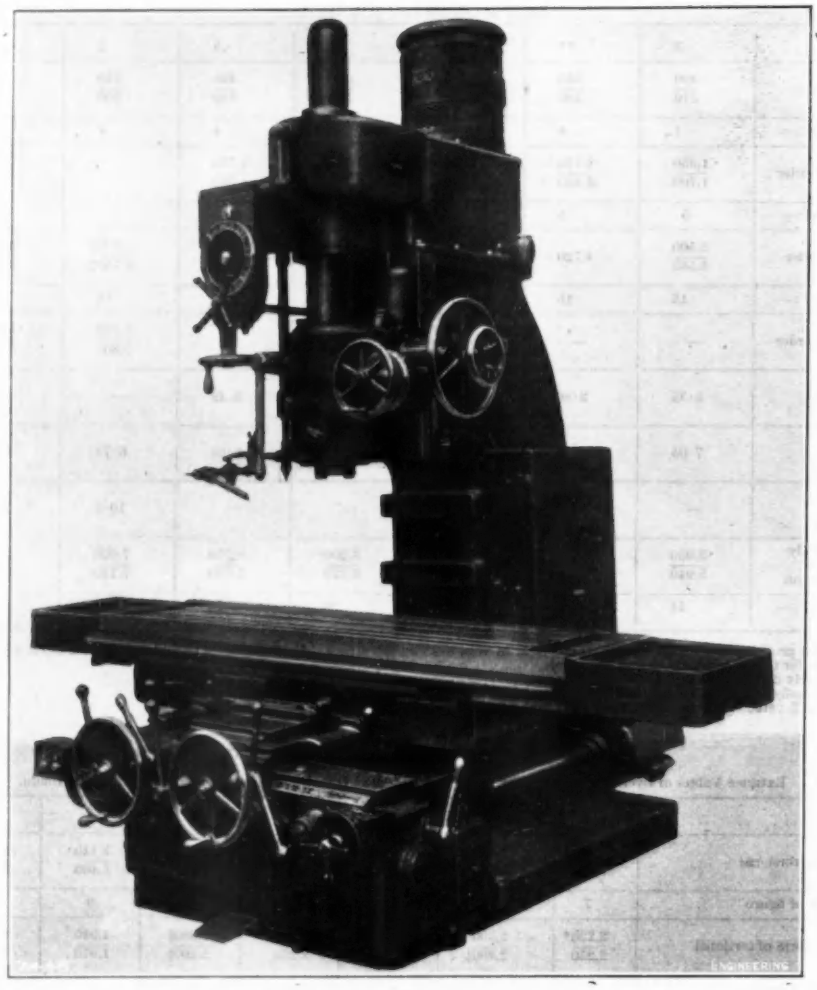
Mineral Production in Quebec.—Statistics issued by the Bureau of Mines of Quebec show that during the first nine months of the present year 249,219 tons of asbestos, 752,295 oz. of gold, and 948,403 oz. of silver were produced. The totals for the corresponding period of 1939 were 246,889 tons of asbestos, 720,285 oz. of gold, and 852,937 oz. of silver.

The Institution of Electrical Engineers.—The Council of the Institution of Electrical Engineers has published a revised (December, 1940) edition of the "Model Form of General Conditions C," for the sale of goods other than cables, in this country, without erection. Copies may be obtained from the Secretary of the Institution or from the publishers, Messrs. E. and F. N. Spon, Limited, 57, Haymarket, London, S.W.1, price 9*d.* each, postage extra. No additional clauses for use with these "Conditions" during the present war have been published.

Teak Thinnings for Paper Making.—In connection with the teak plantations which have been established in Trinidad, it was desired to ascertain whether an outlet could be found for the young thinnings as a source of paper pulp. Material was therefore sent over by the Conservator of Forests in order that the necessary trials could be carried out at the Imperial Institute, London. In a report of the Institute, quoted in the current issue of *The Paper-Maker*, it is concluded, as a result of these trials, that young teak thinnings would not be a promising raw material for paper making, owing to the short length of the ultimate fibres and the difficulty experienced in producing an easily bleachable pulp.

VERTICAL MILLING MACHINE.

MESSRS. ALFRED HERBERT, LIMITED, COVENTRY.



VERTICAL MILLING MACHINE WITH FIXED-BASE TABLE.

A good example of a modern knee-type milling machine constructed by Messrs. Alfred Herbert, Limited, Coventry, was described and illustrated in Engineering, vol. 149, page 591 (1940), and we now propose to deal with a vertical milling machine recently developed by the same firm. This machine is of the kneeless type, that is, the table is supported on a solid base and, therefore, cannot be altered in height, different depths of work, or variations in depth of cut being provided for by traverse of the milling head. The knee-type machine was mentioned so that a comparison may be made between it and the new kneeless machine illustrated in the accompanying figure, this machine being known as the Herbert No. 47 V vertical milling machine. The kneeless machine possesses all the advantages of the knee-type machine, though it is, perhaps, somewhat more convenient and easier to operate owing to the fact that the table controls are always at the same height. The solid base, of course, adds greatly to the rigidity of the machine, and this rigidity, coupled with the employment of a more powerful motor, enables heavy roughing cuts to be made on hard steel. At the same time, the high degree of accuracy with which the machine is constructed, together with the wide ranges of spindle speeds and feeds provided, enables fine finishing work to be done efficiently and rapidly.

The capacity of the machine may be assessed from its leading dimensions. The table has a working surface of 72 in. by 17 in., an automatic longitudinal feed traverse of 48 in., and an automatic transverse feed traverse of 16 in. The spindle head has a vertical adjustment of 16 in. between the maximum and minimum limits of 23 in. and 7 in., respectively, measured from the spindle nose to the surface of the table. The distance from the spindle axis to the face of the column is 16 in. The spindle is driven by a 7½-h.p. reversing electric motor and the table traverse by a 2-h.p. motor, the electrical gear being so arranged that should any fault develop in the spindle motor or an overload be put on it, the table traverse motor is automatically stopped. Starting and stopping is normally effected by the operation of four push-buttons on a small panel to the left of the table bed, two of these buttons controlling the machine proper, while the others start and stop the small motor driving the cutting-lubricant pump. Apart from this, the spindle can be started, stopped or reversed by operation of the lever seen immediately above the panel.

The motor drive is transmitted to the spindle through a train of spur gears which are heat-treated and have ground teeth. The gears run in oil and as they are reduced in number to a minimum and are mounted on stiff shafts running in ball and roller bearings, maximum efficiency of transmission is ensured. No clutches are needed, as the motor is controlled electrically. The motor is mounted on top of the gear-box containing the transmission and spindle-speed change gear. Sixteen changes are provided in slow and fast groups, the first group consisting of eight speeds ranging from 21 r.p.m. to 109 r.p.m., and the second from 144 r.p.m. to 750 r.p.m. The changes are set by the capstan wheel seen to the left of the head, movement of the wheel rotating the large dial above it until the desired speed is opposite a pointer. The handwheel below the capstan wheel selects either the fast or slow range, and at the same time moves the pointer to suit the two sets of graduations and to indicate on a separate plate which range is in use. The spindle saddle, as already stated, has vertical traverse on ways on the column. It is raised or lowered by the two handwheels visible on its right-hand side, the smaller of which actuates a clutch, while the operation of the larger one effects the traverse. Fine adjustment for putting on the cut is made by means of the handwheel in front of the saddle, the clutch being engaged to enable it to function. A micrometer dial on the handwheel facilitates precise adjustment. When the saddle has been set it is firmly locked to the column

SAFETY-LINE MARKING MACHINE FOR ROADS AND FACTORIES.

MESSRS. B.M.B. ENGINEERING COMPANY, LONDON.

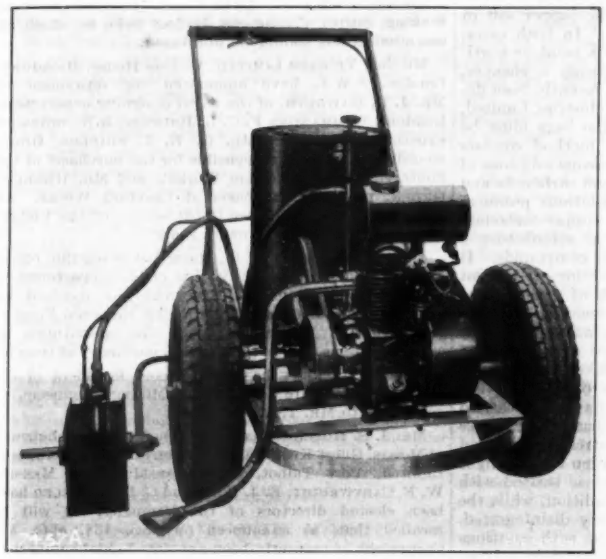


FIG. 1.

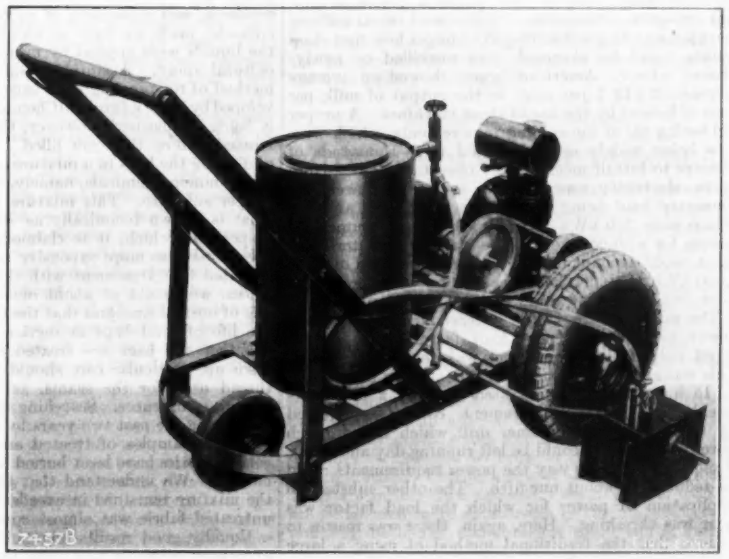


FIG. 2.

by the operation of the long lever seen in line with the adjusting wheel. The saddle is, of course, balanced, so that traverse is easy and locking effective. The gear seen to the left of the locking lever is part of the cutting-lubricant piping, the supply of lubricant being derived from the motor-driven centrifugal pump previously alluded to; this pump is fitted if steel parts are to be machined.

The spindle is of the type normally fitted to the firm's milling machines, *i.e.*, of case-hardened nickel-chrome steel mounted on precision-type ball and roller bearings, an arrangement providing great rigidity and obviating any tendency to vibration under heavy cuts.

The spindle has a standardised nose with non-stick taper and standard clutch. Provision is made for securing cutters directly to the spindle and a draw-bolt and adaptor for securing arbors and cutters with a No. 11 B. and S. taper shank is included in the equipment. The spindle runs in an oil bath in the saddle housing.

The table, as will be clear from the figure, is exceptionally deep and is of strong box section with numerous ribs. It has a long bearing surface on the saddle and is traversed by a rotating phosphor-bronze adjustable nut on a fixed non-splined feed screw of large diameter and coarse pitch. The thrust of the cut is taken on ball thrust bearings. For both the longitudinal and transverse traverse motions, 24 reversible automatic feeds are provided, the range being from $\frac{3}{4}$ in. to 60 in. per minute. The longitudinal motion has a rapid traverse of 200 in. per minute but for the transverse motion the highest feed rate is employed as a rapid traverse. All the table motions, as indicated earlier, are derived from an independent motor. This is seen to the right of the figure underneath the right-hand end of the table with its driving shaft entering a gear-box at the front of the table bed. The 24 feeds are divided into three groups, viz., coarse, medium and fine. The change from one group to the other is made by operation of the lever at the side of the gear-box. The particular feed required is selected by rotating the capstan wheel near this lever until the rate indicated on a cylindrical dial is opposite a pointer. The pedal at the centre of the table bed is depressed when changing the feed range and released again after the change. The lever seen to the left of the feed gear-box reverses the direction of the feed.

The feeds are the same in both the longitudinal and transverse traverses, this being an advantage when milling work which requires a change of motion, such as the triangular ports of locomotive piston valves. Engagement of the longitudinal feed is effected by means of the lever to the right of the large handwheel immediately above the pedal, the lever to the left of the handwheel actuating the rapid traverse mechanism. The lever farther to the left operates the transverse traverse feed. The function of the final lever in this row has been referred to already, but it may be mentioned that when using the rapid traverse, the spindle may be stopped by this lever so that the revolving cutter need not be passed back over a finished piece of work. The two wheels in front of the table bed are for the hand traverse of the table in its two directions. They are arranged close together for the greater convenience of the operator when engaged on die-sinking and similar work in which automatic feed is, generally, unsuitable. The rapid traverse for the longitudinal table motion is independent of the feed traverse and may thus be engaged, without setting any other levers, immediately the feed has been automatically tripped. This rapid-traverse control lever is moved in the direction in which the table is required to travel and can be operated whether the spindle is rotating or not. If the lever is put into the vertical position, the table stops without it being necessary to operate any feed levers. Both the feed and rapid traverses are provided with automatic and dead stops. A lever is fitted for locking the saddle to the table bed.

The electrical gear is housed in a cabinet on the right of the column. The main driving motor is controlled by a star-delta contactor with a three-phase current supply, and by series-parallel contactors with direct current, in conjunction with a lever-operated switch. The machine is completely self-contained as regards wiring. The machine, as illustrated, is the normal type, but, if desired, it can be fitted with a circular table, 24 in. in diameter. This table is driven by a self-contained motor through a feed gear-box giving six rates of reversible automatic feed, hand feed being also arranged for. The electric controls are laid out in such a way that the table driving motor stops when the main motor and cutter spindle is stopped. The machine as illustrated, with a rectangular table, requires a floor space of 12 ft. 6 in. by 6 ft. 11 in.

ROAD-LINE MARKING MACHINE.

ALTHOUGH this article deals mainly with a road-line marking machine, the machine may also be used for marking the safety lines in large factories, both inside and outside buildings, the restricted lighting still prevalent in some factories making safe and efficient traffic otherwise risky and slow. The machine illustrated in Figs. 1 and 2, on this page, is manufactured by Messrs. B.M.B. Engineering Company, Britannia House, Ampton-street, London, W.C.1, and is known as the Rytecraft "Safeti-line" road marker. It is hand-traversed on three wheels, and the paint spray is operated by a pump driven through a Vee-belt by a four-stroke cycle air-cooled petrol engine of $\frac{3}{4}$ h.p. The overall length is 3 ft. 6 in., the width 2 ft. 8 in., and the height from the ground to the handlebar is adjustable between 2 ft. 8 in. and 3 ft. 2 in. The two front wheels are of the steel-disc type, with pneumatic tyres, 16 in. in diameter by 4 in. wide. The rear wheel is solid-rubber tyred and has spring-controlled lateral movement to facilitate steering.

The construction of the frame will be clear from both figures, the main members being of angle iron. Bumper bars are fitted at each end. The engine is governor controlled and has its own lubricating system. The petrol tank is situated above the cylinder, and a fan directs the cooling air over the cylinder by the cowling seen to the right in Fig. 1. An unusual feature seen in this view is the disposition of the engine exhaust pipe, this being led to a point just above the ground surface and terminating in a flattened nozzle close to the paint-spraying device. The effect of this exhaust discharge is to blow away dust, gravel, etc., from the path of the sprayer. The paint is carried in an air-tight container with a capacity of 7 gallons, and the pump is situated between it and the engine, as shown in Fig. 2. The lead of the pump discharge pipe, which is a flexible hose, can also be seen in this view, and it will be clear that there is a connection to the top of the container. The delivery pressure is controlled by a by-pass arrangement, the paint flow being fully automatic, that is, restriction or stoppage of the flow at the sprayer causes a flow back to the container of a portion or the whole of the paint, as the case may be, the paint in the container being thus kept constantly stirred. The sprayer is controlled by a lever on the handle bar, through a Bowden wire. The box seen surrounding the sprayer incorporates a shielding device to give sharp definition at the sides of the lines. This box is carried on a cranked rod so that it can be rapidly raised or lowered. The width of the strip can be varied between 3 in. and 9 in. The sprayer is centrifugal and self-cleaning, and can be adjusted to suit the particular kind of surface being painted. The machine is operated by one man when marking either continuous or interrupted lines, and will work effectively at any speed between 2 m.p.h. and 4 m.p.h. It may be noted that the engine, pump and other working parts are completely protected by a portable covering, this having been removed for the purpose of taking the photographs reproduced in Figs. 1 and 2.

ELECTRICITY IN AGRICULTURE AND HORTICULTURE.

(*Concluded from page* 467.)

THE report on "The Application of Electricity to Agriculture and Horticulture," by Mr. C. A. Cameron Brown, an abridgment of which was given on page 466 of our issue of December 13, is now open to written discussion by members of the Institution of Electrical Engineers in the *Journal* of which it will be published. Mr. H. W. Grimmitt, who was chairman of the committee responsible for the report, in opening this discussion in a written communication which has been circulated, said it was intended to provide information on past work and to make constructive suggestions for future work. Investigations on the load factor of grinding mills, the ultra-violet irradiation of poultry-heating of poultry-rearing plant, soil heating, soil sterilising and the heating of grain-sprouting cabinets.

had already been put in hand. The pressure of modern legislation, control and financial inducement had combined to make it more and more difficult for the dairy farmer to survive without modern plant and appliances. There was more need for a thorough investigation of the whole opportunity for electricity in running a well-balanced dairy farm in view of the appreciable load and revenue obtainable. The mechanical-milking machine was an outstanding example of how first-class results could be obtained with unskilled or newly-trained labour. American figures showed an average increase of 112·7 per cent. in the output of milk per hour of labour by the use of these machines. A proper tightening up of the cooling requirements, which were now being widely evaded, would force thousands of farmers to install mechanically-operated plant. Here again, electricity was the best source of power, the connected load being from ½ h.p. to 1 h.p., and the return some 500 kWh to 1,000 kWh per consumer per annum for a 30-cow herd. The washing and sterilising plant might account for a further consumption of some 5,000 kWh to 10,000 kWh per annum. On the poultry farm, too, electricity could play an important part.

The main feature of the general farmyard or barn power load was its poor load factor. One of the worst culprits in this respect was the grinding mill. This was generally of the plate type, taking from 5 h.p. to 15 h.p., the mill being used for only a few hours weekly. A great improvement could be effected by using a smaller hammer mill which had a much lower capacity and could be left running day and night, if required. In this way the power requirements could be reduced to about one-fifth. The other substantial application of power for which the load factor was poor was threshing. Here, again, there was reason to believe that the traditional method of using a large machine requiring 12 h.p. could be modified to enable corresponding work to be done over a longer period with a power unit of half the capacity.

In horticulture, the main applications for electricity were in providing heat for warming soil and glass houses, and for sterilising soil. So far it had not been possible to justify large scale glass-house heating with electricity. There were, however, ways in which electricity could be used with advantage in assisting the main heating system. It could, for instance, be used as a booster—both mechanical and thermal—for points where the normal circulation was weak. In the amateur's greenhouse the position was better, as he was not so generally concerned with the cost of running and freedom from the trouble of firing was an attraction. Soil heating was another application where the amateur's position was much happier, although its development for large scale commercial hot-beds was in its early stages. All that was required here was an authoritative codification of the applications. Soil sterilising was practised in many places, but again the technical difficulties and the cost of sterilising large quantities of soil tended to obscure its possibilities for the small nurseryman and amateur. The lighting of growing crops to control their maturing was another application, and this was going through the stages of sorting out a mass of miscellaneous experimental information and establishing lines of commercial applications. Of the many other miscellaneous applications of electric power and heat, the drying of grain and grass crops was important. Ultra-violet irradiation had wide possibilities for the therapeutic and conditional treatment and control of livestock. It had also been applied to milk. There was every likelihood that there might be great advances in the use of the sprouting of grain in cabinets. Electro-culture, or the discharge of electricity on and to growing crops, had been the subject of much wild talk and equally wild experimental work. Despite certain individual and peculiar instances of exceptions, the eighteenth report of the Ministry of Agriculture seemed to dispose of this application as a practical proposition. Electric ploughing, too, had been the subject of much wishful thinking and special pleading. The truth was that this kind of power application was the least suited to electrical operation.

The electricity supply industry was technically in a position to supply the majority of farms in this country. There were two reasons why most of the farms were not taking a supply, however, and these were the cost of giving a service and the cost of wiring the farm and the plant. There was scope for research to determine, on the one hand, how the cost of giving rural supplies could be reduced, and how, on the other hand, the rural load could be developed with economic justification to the farmer himself so as to attract supply on a scale which, under present conditions of use, was too often far from economic to the supplier.

REGISTRATION OF NEW MOTOR VEHICLES.—Statistics which have been issued recently show that 4,376 new motor road vehicles were registered in September, 1940, compared with 17,738 in September, 1939. As was to be expected, the greatest declines took place in the private-car and goods-vehicle categories.

ROT-PROOFING OF SAND BAGS.

JUST over a year ago* we gave particulars of two types of preservatives, advocated by the Minister of Home Security, for the rot-proofing of sand-bags used for revetments. These preservatives, it may be recalled, comprised a creosote or tar distillate, used as a water emulsion, and a solution of an organic copper salt in creosote, made up into an emulsion. In both cases, the liquids were applied by means of a paint or horticultural spray. A simpler, and certainly a cheaper, method of rot-proofing sand bags has recently been developed by Messrs. Imperial Chemical Industries, Limited, it being emphasised, however, that the bags must be treated before they are filled. The method consists of dipping the bags in a mixture of aqueous solutions of two common chemicals, namely, sodium carbonate and copper sulphate. This mixture of solutions produces what is known technically as basic copper-carbonate suspension, which, it is claimed, is as satisfactory a preservative as more expensive copper compounds. It is stated that treatment with this mixture, at present prices, works out at about one-tenth of a penny per bag of normal size, and that the treatment will increase the life of sand bags in service at least eight times. Whether the bags are treated before or after being sewn up, particular care should be taken to treat the thread used for the seams, as it is often here that rotting commences. Searching tests have been carried out during the past two years by the firm, in the course of which samples of treated and untreated jute and cotton fabrics have been buried in garden soil for eight months. We understand that the fabric treated with the mixture remained in excellent condition, while the untreated fabric was almost completely disintegrated.

Equally good results were obtained with solutions of copper sulphate and soda used separately. It is, of course, simpler to use the one-bath process, but, in treating compact and tightly-woven materials, or sand bags in compressed bales, it is pointed out that it may be preferable to adopt successive immersions into copper sulphate and soda solutions. The liquor for the one-bath process is made up in the following manner: A solution of 4½ lb. of soda ash or of 11½ lb. of washing-soda crystals, in 5 gallons of water, is poured slowly, with constant stirring, into a solution of 10 lb. of copper sulphate in 30 gallons of water. A 50-gallon wooden vessel should be employed, for obvious reasons; not one of iron or of galvanised iron. The mixture is finally made up to 40 gallons with water and 2 oz. of Calsolene oil H S is added. This is a "wetting" agent, which assists in the penetration of the fabric by the liquor and adds very little to the cost of the bath. After a final thorough stirring, the bath is ready for use. The sand bags should be immersed until they are thoroughly saturated. When the bath is used cold the bags should remain in it for at least 5 minutes, but the process may be speeded up by maintaining the bath at a temperature of between 30 deg. and 40 deg. C. (85 deg. to 100 deg. F.). Upon removal from the bath the excess liquor should be removed by wringing or by using a hydro-extractor. After wringing, the bags should weigh twice their original weight; they should then be dried at a low temperature before being put into service. We are informed that further particulars, including directions for the carrying out of the two-bath process, may be obtained on application to Messrs. Imperial Chemical Industries, Limited.

BOOKS RECEIVED.

Ministry of Works and Buildings. Wartime Building Supplies. Schedule of Requirements for Government Departments. Second edition. November, 1940. London: H.M. Stationery Office. [Price 1*s.* net.]

Annual Report and Accounts of the Commissioners for the Port of Rangoon. Year Ended 31st March, 1940. Rangoon: Offices of the Commissioners for the Port of Rangoon.

Commissioners for the Port of Rangoon. Departmental Annual Reports of the Traffic Manager, the Deputy Conservator and the Chief Engineer. Year Ended 31st March, 1940. Rangoon: Offices of the Commissioners for the Port of Rangoon.

United States Coast and Geodetic Survey. Special Publication No. 221. *Triangulation in South Carolina.* (1927 *Datum.*) Part 2. *First- and Second-Order Triangulation and Traverse in the Southeastern Part of the State.* By H. P. KAUFMAN. Washington: Superintendent of Documents. [Price 25 cents.]

Massachusetts Institute of Technology. Department of Civil and Sanitary Engineering. A Theory of Clay Consolidation Accounting for Secondary Compressions. By PROFESSORS D. W. TAYLOR and WILFRED MERCHANT. Cambridge, Mass., U.S.A.: Professor D. W. Taylor, Soil Mechanics Laboratory, Massachusetts Institute of Technology.

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* See ENGINEERING, vol. 148, page 579 (1939).

PERSONAL.

THE Minister of Supply has appointed MR. H. O. SMITH, a director of Messrs. Imperial Chemical Industries, Limited, to be Controller of Small Arms Ammunition.

MESSRS. BRITISH PIGIRONS, LIMITED, have established a temporary office at "Little Court," Pyrford Common, Woking, Surrey (Telephone, Byfleet 587), to which all communications should be addressed.

MESSRS. VICKERS LIMITED, Vickers House, Broadway, London, S.W.1, have announced the retirement of MR. J. L. HAWORTH, of the naval designing department, London; COMMANDER F. G. L. JOHNSON, R.N., ordnance experimental officer; MR. G. R. I. SHIELDS, Group co-ordinating officer, responsible for the purchases of the Southern and Birmingham Works; and MR. HERBERT GREEN, production manager at Crayford Works. All these gentlemen have been in the service of the Vickers Group of Companies for many years.

DR. F. M. LEA, F.I.C., principal scientific officer at the Building Research Station of the Department of Scientific and Industrial Research, has received an award of 100 guineas from the Beilby Memorial Fund in recognition of his researches on the constitution of silicate systems and on the physical chemistry of cement.

MR. H. MASKREY has been elected President of the North Staffordshire Institute of Mining Engineers, in succession to MR. T. C. MAYNARD.

MR. J. S. HOLLINGS has been appointed vice-chairman of Messrs. Guest Keen Baldwins Iron and Steel Company, Limited, Port Talbot, Glamorganshire, and MESSRS. W. F. CARTWRIGHT, E. J. PODE and C. R. WHEELER have been elected directors of the Company. It will be recalled that, as announced on page 468, *ante*, Mr. Cartwright has recently been appointed chief engineer of the works of the firm.

MR. A. J. GRANT, managing director of Messrs. Thos. Firth and John Brown, Limited, Atlas and Norfolk Works, Sheffield, 1, has been elected a member of the Council of the Industrial Welfare Society. Another director of the firm, DR. W. H. HATFIELD, F.R.S., has been elected President of the Sheffield Society of Engineers and Metallurgists, the normal tenure of this office being two years.

MESSRS. SALFORD ELECTRICAL INSTRUMENTS, LIMITED, Silk-street, Salford, 3, Lancashire, inform us that their telephone number has been changed from BLAckfriars 6688 to BLAckfriars 8888.

MESSRS. PRAT-DANIEL (STANMORE), LIMITED, Dalston-gardens, Stanmore, Middlesex, advise us that they will continue the business of fan manufacture for various purposes, especially for boiler plants, dust collectors, and air heaters, hitherto carried on by MESSRS. PRAT-DANIEL, LIMITED. Owing to circumstances arising out of the international situation, it has become necessary to liquidate the latter company, and the new concern will be entirely British.

TENDERS.

WE have received from the Department of Overseas Trade, 99-103, St. Michael's-road, Bournemouth, particulars of the undermentioned tenders, the closing dates of which are as stated. Details may be obtained on application to the Department at the above address, quoting the reference numbers given.

Electric Railway Coaches, comprising 11 second-class coaches, type P. 15M., to seat 68 passengers; 10 third-class motor coaches, type T. 43M., to seat 78 passengers; and the electrical equipment for the motor coaches and for two spare bogie trucks, in connection with the Durban-Hillcrest Electrification Scheme. South African Railways and Harbours, Johannesburg; June 30, 1941. (T. 22,896/40.)

Motor Tractors. In connection with the call for tenders for the supply and delivery of industrial-type, four-cylinder engined tractors, fitted with pneumatic tyres, noted on page 468, *ante*, we now learn that the South African Railways and Harbours, Johannesburg, have extended the closing date from January 6 to January 17, 1941. (T. 23,013/40.)

Turbo-Alternator, 10,000 kW, and two boilers rated at 60,000 lb. evaporative capacity per hour, together with associated auxiliary equipment. Municipality of Bulawayo, Southern Rhodesia; February 17, 1941. (T. 23,329/40.)

Air-Conditioning Plant, comprising heat exchangers, cooling coils, air filters and spare parts, tools, and accessories. City of Cape Town Electricity Department, Strand-street, Cape Town; January 29, 1941. (T. 23,387/40.)

Condensers, five hundred 0·1 mfd., and five thousand 1 mfd. Also 200 four-conductor cords and 200 head bands. Post and Telegraph Department, General Post Office, Wellington; January 29, 1941. (T. 23,413/40.)

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—The announcement that the Government intended to introduce a general levy of 6*d.* per ton on all coal raised in the country so as to provide a fund to assist collieries rendered idle as a result of the diminution of trade has been well received in Welsh coal circles. Employment in the industry and other problems were considered at a special conference of the South Wales Miners' Federation, held during the week, and the Government was urged to intensify its efforts to place facilities at the disposal of the trade which would enable coal sales to be considerably increased both abroad and inland. Brisk conditions ruled on the market during the week for the high-volatile bituminous coals which were in demand by inland industrial users, although new business was checked by the difficulty buyers encountered in arranging for supplies over some time ahead. Dry steam coals, on the other hand, were slow and dull. Best large qualities were provided with steady outlets, and the sized kinds remained scarce. Bituminous smalls were not easily obtained, but dry smalls were offering freely and were dull. Cokes were in good request from home users, but patent fuel was still slow.

The Iron and Steel Trade.—Activities were well maintained in the iron and steel and allied trades of South Wales and Monmouthshire last week. The demand remained brisk, but works were kept busy in fulfilling orders already on their books.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Little change can be recorded in the Scottish steel trade this week, but the demand continues on a heavy scale. The usual consumers are issuing numerous specifications, especially for the lighter sorts, and the demand is steady. Makers of black-steel sheets are being pressed for deliveries of ordinary and galvanised varieties and are well booked ahead. The supply of raw materials is good. Prices are as follows:—Boiler plates, 17*l.* 0*s.* 6*d.* per ton; ship plates, 16*l.* 3*s.* per ton; sections, 15*l.* 8*s.* per ton; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l.* 15*s.* per ton; black-steel sheets, No. 24 gauge, 22*l.* 15*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton.

Malleable-Iron Trade.—Satisfactory conditions continue to prevail in the malleable-iron trade of the West of Scotland and all the works are busy. The re-rollers of steel bars are fully employed on contracts placed recently and all buyers are anxious for speedy deliveries. The following are the current quotations:—Crown bars, 15*l.* 12*s.* 6*d.* per ton; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton; No. 4 bars, 13*l.* 17*s.* 6*d.* per ton; and re-rolled steel bars, 17*l.* 15*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—Very active conditions are general in the Scottish pig-iron trade and the whole output is quickly absorbed. Both hematite and basic iron are in strong demand by steelmakers but more business could be done in foundry grades. To-day's market prices are as follows:—Hematite, 6*l.* 18*s.* 6*d.* per ton; and basic iron, 6*l.* 0*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 6*l.* 5*s.* 6*d.* per ton, and No. 3, 6*l.* 3*s.* 6*d.* per ton, both on trucks at makers' yards.

THE LATE MR. A. DANSIE. We announce with regret the death, at the age of 72, of Mr. Arthur Dansie, at Croydon, on December 10. Mr. Dansie, who was formerly assistant secretary of the Institution of Naval Architects, was in the service of the Institution for upwards of 44 years. He joined the staff in 1892 and retired at the end of February, 1937. At a Council Dinner, held on February 11, 1937, the President, Lord Stonehaven, made a presentation to Mr. Dansie in recognition of his long service to the Institution.

CARBURISING BOXES OF INCONEL.—Reference is made in a recent issue of the United States journal, *Heat Treating and Forging*, to the use made, by the Michigan Steel Casting Company, of Inconel sheet for the manufacture of carburising boxes and annealing containers. These are produced from ¼-in. rolled Inconel sheet, which alloy is of the 80 : 14 : 6 nickel-chromium-iron type. The alloy not only strongly resists oxidation and corrosion, but the light weight of the boxes, as compared with the cast containers which they replace, is found to give greater furnace efficiency, since there is less non-productive metal to absorb heat. It is stated that the first Inconel carburising containers, put into service two years ago, are still in excellent condition. The alloy it has been found, does not carburise to any appreciable extent, and, even after long periods of service, it is stated to retain much of its characteristic toughness.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Negotiations for the supply of iron and steel during the first quarter of the new year are proceeding satisfactorily and customers are hoping that the delivery allocations will be rather larger than those of the last quarter of 1940. The heavy total output and the substantial imports of several commodities are sufficient for all essential needs, but leave little tonnage available for other purposes. The strict rationing of buyers continues and licences for the delivery of tonnage for other than war-time requirements are not easily obtained.

Cleveland Iron Trade.—There is still no likelihood of a more regular or larger make of Cleveland pig, the intermittent light output of which contributes little to the increasing demands for foundry iron. The growing activity at the foundries necessitates an appreciably larger consumption of pig, though founders are making liberal use of scrap. Midland iron continues to come to hand in considerable parcels, and an adequate tonnage is obtainable from other producing centres for particular purposes. The fixed prices of Cleveland pig remain at the equivalent of No. 3 quality at 128*s.*, delivered within the Tees-side zone.

Hematite.—The demand for hematite is heavy and increasing. The production is promptly absorbed in supplying running contracts, and the large and increasing requirements of the makers' own consuming plants. Pressure for the supply of local brands, however, has been greatly relieved by the use of American iron, the quality of which is giving complete satisfaction to buyers in this district. At the same time, makers here continue to hold off the market, being of the opinion that their delivery obligations are still too extensive to justify them in entering into further commitments. The stabilised values of East Coast hematite are ruled by No. 1 description at 138*s.* 6*d.*, delivered to North of England areas.

Basic Iron.—Steel makers are receiving ample supplies of basic iron from their own furnaces. The output of this iron is being maintained at a high level, but none is offered for sale.

Foreign Ore.—Consumers of foreign ore have reasonable stocks to draw upon and are confident that imports will continue on a satisfactory scale.

Blast-Furnace Coke.—There are now some sellers of Durham good medium blast-furnace coke at the official figure of 35*s.* 6*d.*, but though the supply is plentiful, holders are not pressing business as their contract commitments are already heavy. Local users are well covered and are not inclined to place further orders.

Manufactured Iron and Steel.—Semi-finished iron and steel deliveries fully satisfy the large requirements of the re-rolling mills. Makers of all kinds of sheets are turning out maximum tonnages, and have contracts to execute that prevent them from accepting new orders, except for delivery well ahead. Steel producers are heavily sold and are very busily employed. There is a strong demand for shipbuilding requisites and for steel for constructional engineering. Soft steel billets are quoted at 12*l.* 5*s.*; hard billets at 13*l.* 12*s.* 6*d.*; joists and sections at 15*l.* 8*s.*; heavy plates at 16*l.* 3*s.*; and heavy rails at 14*l.* 10*s.*

Scrap.—Stocks of iron and steel scrap at users' yards are heavy, but deliveries are still accepted and buyers of certain descriptions are inclined to make further forward purchases.

DATA ON INDUSTRIAL ELECTRIC MOTORS.—Messrs. Newman Motors, 32, Victoria-street, London, S.W.1, have sent us a copy of a neat little cloth-bound booklet dealing with electric motors for driving machine tools and other machines. The data given include lists of the approximate horse-power required to drive machinery of various types, and tables showing the full-load current of motors, the sizes of V.I.R. cables, and the approximate running cost, per hour, of 50-cycles, three-phase motors, ranging from ¼ b.h.p. to 10 b.h.p.

THE ORGANISATION OF TRAFFIC AREAS IN SCOTLAND.—The Secretary to the Ministry of Transport informs us that the term of office of Mr. H. Riches, O.B.E., Chairman of Traffic Commissioners for the Northern Scotland Traffic Area, expires on December 31, 1940. The Minister has decided that for the period of the war it is desirable to bring the traffic areas in Scotland into line with the regional organisation, and he has therefore made an Order combining the two traffic areas in Scotland into one traffic area. Mr. A. Henderson, who is the Regional Transport Commissioner for Scotland, and the Chairman of the Southern Scotland Traffic Area, has been appointed Chairman of Traffic Commissioners for the combined area. Mr. A. Robertson, M.B.E., has been appointed Deputy to Mr. Henderson; he will be stationed at the office of the Commissioner at Aberdeen.

NOTICE OF MEETING.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Scottish Branch, Falkirk Section:* Friday, December 20, 7 p.m., The Temperance Café, Lint Riggs, Falkirk. Discussion on the Report of the Melting Furnaces Sub-Committee of the Technical Committee.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The Christmas shut-down at all the large steel and engineering works in this area will be a short one. Some firms will have one day's break, but others will take two or three days, which will enable urgent repairs to be carried out to furnaces and machines which have been turning out record tonnages for the last three months. Inquiries at steel-producing concerns show that all types of steels are in heavy demand. Not only are raw and semi-finished steels in strong request, but there is great activity in the production of all types of high-efficiency steels. Despite the record demand, producers are still able to obtain adequate supplies of pig iron, hematite, scrap, and steel-making alloys. No difficulty is expected to arise in the future supply of such materials. Cutting steels of all types and stainless steels are in increased demand. Stainless-steel castings are being used more extensively in the manufacture of pumping machinery, steam-raising plant, and in various branches of civil engineering. Business in electrical plant is increasing, and quarrying machinery is in heavier demand. Metal-mining enterprises abroad continue to rely on Sheffield for supplies of boring machines, washing and refining equipment, dredger gears and parts made of abrasion-resisting steel, and large steel balls for crushing purposes. The requirements of the coal industry are also increasing, among the best lines being steel props and coal-cutting machines. Machine and engineers' small tools are in record demand. File-making works are busier than they have been for many years, the majority of orders being on inland account. Overseas trade shows slight improvement.

South Yorkshire Coal Trade.—More fuel is being sold on inland account. Industrial consumption accounts for a heavy tonnage, but users report that there is no difficulty in obtaining ample supplies. Steam-raising coal is in strong demand, and the deliveries of smalls and slacks to electric power stations have been maintained. The house-coal market is more active.

THE W. E. HIGHFIELD SHIELD COMPETITION.—The Board of Examiners has recently announced its decision in regard to the W. E. Highfield Shield Competition, held under the auspices of the Association of Supervising Electrical Engineers. The Shield and first prize of 5 guineas, including a replica of the Shield, has been awarded to Mr. G. A. T. Burdett, London, for his paper "Some Aspects of the Use of Electricity in Aircraft." The second prize of 3 guineas has been won by Mr. R. H. L. Andrew, Macclesfield, for his paper "Pride of Industry," while the third prize of 2 guineas has been gained by Mr. A. E. Payne, London, for his paper, "What is Power Factor?" The Shield and prizes will be presented to the successful competitors early in the New Year.

MAP OF THE COLONIAL EMPIRE.—We have received copies of a new map of the Colonial Empire, published by *The Crown Colonist*, 33, Tothill-street, London, S.W.1. This is designed to show the situation and sizes of our Colonies in relation to one another and to the British Isles, and consists of a map of the World, on Mercator's Projection, on which Great Britain and Northern Ireland, the Crown Colonies, Protectorates and Mandated Territories are shown in deep red. The South African Protectorates, administered by the Dominions Office, are shown in red hatching, Condominium Territories such as the Anglo-Egyptian Sudan, by a red stipple, while the Dominions and their Dependencies are coloured pale red. The rest of the world is coloured yellow. Shipping routes, submarine cables and the principal coal and oil-fuel stations are shown, while the main air routes are also indicated. Supplementing the general map are insets showing the various Colonies and Protectorates, and all these, together with a separate inset map of Great Britain and Ireland, are drawn on a uniform scale of 1 : 10,000,000 (approximately 160 miles to the inch). Statistics concerning area, population, exports, imports, etc., of individual countries of the Colonial Empire are also included. The map measures 37 in. by 48 in., and in sheet form, unmounted, the price is 6*s.* net. Mounted on cloth with rollers, and varnished, or on cloth, dissected for folding, the price is 15*s.* net.

FAILURE OF THE TACOMA NARROWS BRIDGE.

(*For Description, see page* 481.)

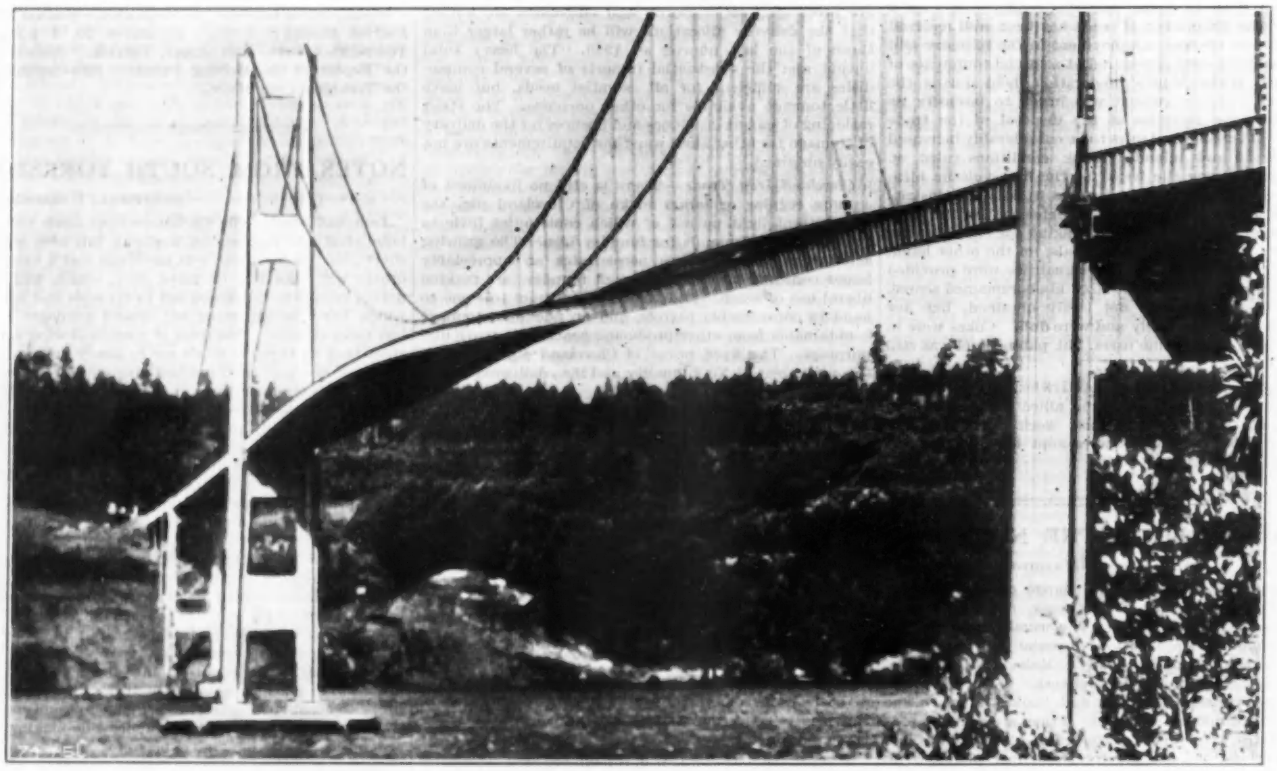

Fig. 3. Deck Twisting Shortly Before Failure.

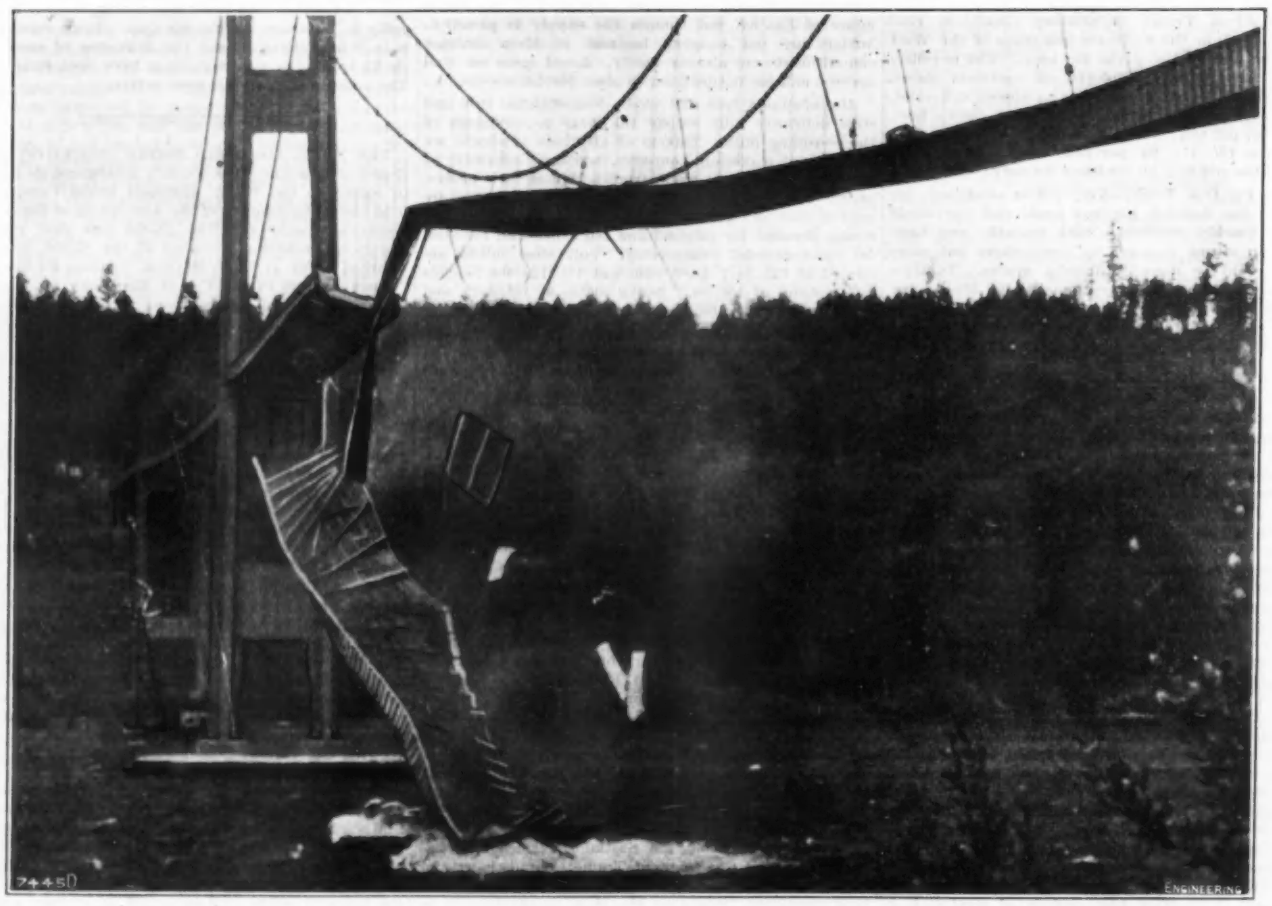

Fig. 4. Section of Roadway Falling into Puget Sound.

ENGINEERING.

Offices for Publication and Advertisements, 35 & 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and other publications bearing somewhat similar titles.

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"ENGINEERING" may be ordered from any newsagent in town and country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months (or for six or three months, *pro rata*), payable in advance :—

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Thin paper copies	£2	18	6
Thick paper copies	£3	3	0
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Thin paper copies	£3	3	0
Thick paper copies	£3	7	6

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When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines, or under, and one shilling per line up to one inch. The line averages six words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns, of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

All accounts are payable to "ENGINEERING," Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W C.2.

TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

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ENGINEERING

FRIDAY, DECEMBER 20, 1940.

VOL. 150. No. 3910.

COSTING ON GOVERNMENT CONTRACTS.

"To Woolwich to the Rope-yard," wroté Samuel Pepys, in his diary on July 21, 1662, "and there looked over several sorts of hemp, and did fall upon my great survey of seeing the working and experiments of the strength and the charge in the dressing of every sort; and I do think to have brought it to so great a certainty, as I have done the King some service in it." Then came the typically shrewd Pepysian comment, that "I see it is impossible for the King to have things done as cheap as other men." The reasons why this should be do not need to be discussed in detail. The *Diary* indicates sufficient of them to show how it has come about that the checking and counter-checking of departmental costs has developed into such an important feature of Civil Service routine; and it is not difficult to realise why, when circumstances compel a Government department to extend its costing investigations extra-departmentally, and to maintain its own independent check upon the finances of commercial undertakings, its methods and theirs may present divergences of practice that are likely to lead to fundamental differences of opinion. In a Government department, costing is primarily a means to ensure that the expenditure is kept within the limits of funds already voted for its particular purposes, and time is much less important than in a business firm, where accuracy must be combined with rapidity and economy of costing.

In normal times, when manufacturers can buy materials freely in favourable markets and thus can plan their production with a reasonable certainty of being able to work to the intended programme and estimate, the ordinary methods of contracting provide all the assurance of fair dealing that most contractors and customers require. The need for independent checks on costing only arises when artificial controls are introduced, or if other circumstances make the observance of long-term contracts impracticable; but it is not always realised that the expense of these extra checks may in themselves represent an appreciable addition to the cost of production, especially if the customer is a Government department which is in a position to insist that the returns shall be made in a particular way, without reference to the established practice of the firm concerned. This was well illustrated in the case of shipbuilding, for Admiralty account, during the war of 1914-18. All the ships under construction at the outbreak of the war were being built under contract and for nearly a year the effort was continued to retain this basis, with appropriate adjustments to compensate for the rising costs of materials and labour. Increase succeeded increase at such a rate, however, in material and labour costs and in overhead charges, that contracting became quite impracticable, and, in 1915, the system was introduced of payment on the basis of net cost plus an agreed percentage of profit.

Almost at once it was found that, in dealing with such highly technical products as ships and their machinery, some more specialised knowledge was required than could be brought to bear by the average temporary accountant official; and it became necessary to provide the overseers, whose duty it was to certify the periodical claims for payments on account, with additional technical assistants, who maintained a general supervision over the records of costs to see that the charges made were appropriate to the materials and processes which they covered. Thus there were, in every case, at least three separate costing examinations in progress; namely, the builders' own system (which varied widely between different firms), the Government accountants' investigation, and the check by the overseeing staff; and it is not hard to see how, in such circumstances, "it is impossible for the King to have things done as cheap as other men."

Stringent as were the costing investigations of the previous war, those of the present conflict are even more so, as a result of the imposition of the 100-per cent. Excess Profits Tax and the all-embracing powers of inquisition conferred upon the various supply departments by war-emergency legislation; and experience has shown how urgent is the need for some simplification of the system under which each department finds it necessary to maintain its own supervisory costing staff. The need is especially evident in the case of firms who may be working simultaneously on orders for several departments of the war services. General approval will certainly be given, therefore, to the action of the Internal-Combustion Engine Manufacturers' Association in formulating the scheme of cost investigation, particulars of which have been recently announced.

The scheme is put forward by the Executive Committee of the Association, which consists of representatives of seven firms engaged in this branch of manufacture, with Sir Lyndon Macassey as independent chairman; and has been agreed between the Association and the chief officials of the costing branches of the Admiralty, the Ministry of Supply and the Air Ministry, acting on behalf of the Contracts Co-ordinating Committee, which consists of the Director of Naval Contracts and the Directors of Contracts of the Ministry of Supply and the Air Ministry. In the words of the introductory memorandum, it "applies to all the large category of Government contracts in which there is a term to the effect that the contract price shall be a reasonable price to be mutually agreed having regard to costs," and is designed to avoid the drawbacks of the system "under which cost investigators of the three Departments independently checked costs for all of such contracts without any uniformity of procedure either on the part of the investigators or the members of the Association." Although intended, in the first place, to apply only to contracts for the manufacture of internal-combustion engines, it has been so devised as to be applicable "to contracts of the same category for any engines, appliances, or things manufactured by members of the Association within any range of engineering production."

The principal features of the scheme, as outlined in the memorandum, are as follows. Costing data (the nature of which is specified) are to be given to Government departments only in cases where actual costs are required under the terms of the contract, but are not to be given for standard products unless the departments concerned have reason to doubt that the price is reasonable. Each firm's financial and cost accounts will continue to be available to the Government's cost investigators for scrutiny or for a "spot" check of individual

costs, if required. Firms will furnish to the Supply Departments certain statements of costs; details of the basis on which they are prepared; copies of their annual accounts as submitted to the shareholders, and of the audited balance sheet and accounts, together with profit and loss statements showing total sales, direct wages and materials, and works overhead, administration and selling charges; and statements as to the recovery of oncosts. These financial statements are to be prepared in a uniform manner, and some will require to be certified.

When the scheme is brought into operation in connection with a given firm, the Government Supply Departments will require to satisfy themselves that the basis of preparation of costs is reasonable, but they undertake not to ask for it to be changed unless they consider that it presents some fundamental error in principle which results in incorrect costing. It is recognised, as the memorandum observes, that to ask for a uniform system of costing for all the diverse businesses of members of the Association would involve difficulties, even under normal conditions; but a few recommendations are made, regarding the allocation of certain items, the adoption of which will have the effect of simplifying the presentation of the necessary returns and the task of dealing with them in the departments concerned. For example, the desire is expressed that "direct materials" should be charged at their actual cost, including inward carriage, the term "actual cost" being deemed to include any system of averaging, using the earliest purchases first. This gives the Government the benefit of any favourable purchase of stocks, while safeguarding the firm by ensuring that, if prices subsequently fall, payment will be made of the actual expenditure represented by the materials. Direct labour should be limited to operatives' wages only, wherever possible, foremen and supervision being charged to overhead expenses. Works overheads should be taken as a percentage of direct labour; and commercial charges should be expressed, where practicable, as a percentage of the total works cost.

By the adoption of the scheme, it is hoped to secure five principal advantages. First and foremost, it will avoid the present overlapping cost investigations by three separate departments, as it will be operated by the Ministry of Supply on behalf of all three. Secondly, it ensures a uniformity in the method of investigation. Thirdly, there is the very considerable advantage that, where standard products are involved, and the costs have once been determined, all the departments will accept those costs, subject to the right to make "spot" checks. Fourthly, it is expected that the speedier determination of costs and, consequently of contract prices, will obviate delays in making the final payments due under contracts. Finally, the visits of costs investigators to works, and the discussion of costing questions, which hitherto have called for such an expenditure of time and trouble, will be reduced to a minimum. These are very appreciable benefits, and the enjoyment of them on the widest possible scale should go far to relieve the engineering industry of a burden which has been bearing heavily on many firms, while the incidental advantage to the taxpayer (who has to meet the actual costs as well as the expense of ascertaining and checking them) should be far from negligible. It is emphasised in the memorandum that the Executive Committee of the Internal Combustion Engine Makers' Association, in negotiating the agreement with the Government Departments, had authority only to apply it to engines coming within the scope of the Association, and produced by member firms. The scheme has been framed, however, so as to be generally applicable to the manufacture of all engineering products; and an assurance has been received that the Admiralty, the Ministry of Supply and the Air Ministry are prepared to consider its general application. They have the necessary power to do so in any case, without prior agreement, but it would appear, from the wording of the statement, that they would prefer the various manufacturers' organisations, in the different branches of the engineering industry, to take the initiative, rather than resort to compulsion. *Prima facie*, it does not seem likely that any compulsion will be necessary.

THE COMPLETE ENGINEER.

Some time ago, a well-known publishing house specialising in serial works commenced the issue of a compendium bearing the comprehensive title of *The Complete Engineer*. It was designed to cover a very wide field in order to provide for the turner, draughtsman, patternmaker, or other craftsman, an opportunity to learn something of each other's occupations, and the adjective "complete," obviously was intended to apply specifically to its technical range. The term is capable, however, of another, and, perhaps, a truer interpretation; although the thoughtful man may be inclined to smile, it may be a little wryly if he is getting on in years, when he reflects on the gaps in his own knowledge, on his halting expression of the little that he knows and on his apparent inability to influence the course of events outside of his own profession. He may ask himself how far he is a complete engineer if he is virtually ignorant of the mechanisms and processes of Nature; or feel annoyance that what he thought he had put so clearly has been misconstrued, and disappointment that engineers as a body should carry so little weight in the affairs of the civic community. The professor and the teacher will maintain, no doubt, that such shortcomings are due to deficient education, and the psychologist will talk learnedly of inherent characters and response to stimuli, but none of these academic experts can draw up a syllabus, or indicate a method of analysis, which can be relied upon to produce specific results. It is significant that the great engineers of the past, self-educated as most of them were, seemed to approach nearer to completeness, to use the term in its more expansive sense, than does the man who has been subjected in his earlier years to deliberately-planned courses of education and to so-called intensive training. It would seem, indeed, that these *ad hoc* methods succeed better with the performing animal of the circus than with the human being, and, logically, their outcome would appear to lie in the production of the one-idea'd specialist drawn so vividly, if with some acidity, in Mr. H. G. Wells's *First Men in the Moon*. Such strictures are not intended to imply that conventional educational methods do not produce engineers; merely that they cannot produce the complete engineer.

Most of the inarticulateness of the average engineer (and it is only necessary to attend the discussions at any technical institution, or to read some of the manuscripts submitted for publication in technical journals, to realise how generally it exists) may be due largely to the neglect in educational curricula of that old "humanity," formal logic. Admittedly, it is a dry subject, but some attention to it would give confidence to the hesitant, self-conscious engineer who has something to say that is intrinsically worth hearing. Fortunately, there is no necessity to wade conscientiously through Jevons, John Stuart Mill, or the almost innumerable text-books on the subject when there is in literature so great a body of closely-reasoned material, potentially much more useful to the engineer than the colour and passion of Shakespeare or the colder stateliness of Milton, to mention only two of the staples of the examiner in English. To take a single instance; many engineers know something of Blaise Pascal, his barometric investigations, his contributions to conics and the calculus, and his calculating machine, yet it would be exceptional to find one who has read this Seventeenth-Century physicist's *Provincial Letters*. This work, suggested for its method and not its matter, for it is only the record of a long-dead dispute between Jesuit and Jansenist, contains argument and reasoning of the highest order. The specious plea that the engineer has no time for general reading will always be at hand, but he who uses such an excuse must be content to remain an incomplete engineer; a man who may be able to talk "shop," but who is lost in general company and, therefore, is false to his profession in his inability to demonstrate that the engineer may be as civilised a person as the barrister, the doctor or the diplomat. We have even known an engineer who boasted that he had never read a book of any kind other than a professional text-book, between leaving school and taking his University degree, and this was not a solitary instance.

There is, in aloofness of this kind, almost a suggestion that the engineer of to-day considers the past to hold nothing worthy of his attention, and that science, history, music, art, architecture, and literature are too trifling to think about. The engineers of earlier years had no such illusion; their profession seemed to make them more receptive, more curious, less content with their own limitations. It is curious to note, for example, how many of them seemed to feel that the earth itself was too confining, and sought a wider freedom in the immensities of stellar space. It is recorded of Henry Maudslay how greatly he was impressed by a visit to the Observatory at Berlin, apart from the mechanism of the fine instruments, and how he fired his pupil, James Nasmyth, with such enthusiasm that, in later years, the great Herschel himself did not disdain to commend the services done to astronomy by the inventor of the steam hammer. There is no obvious connection, again, between steel and stars, yet Henry Bessemer was another serious worker in the illimitable field of astronomy. Incidentally, both Maudslay and Bessemer applied their engineering skill in constructing telescopes. To these two outstanding names may be added one in which we have more particular interest, namely, that of Dr. W. H. Maw, Editor of this journal for more than half a century. It is sufficient testimony to his engineering capabilities that Dr. Maw was elected president of the two premier engineering institutions, yet he was also president of the Royal Astronomical Society. Here, again, personal professional knowledge and skill were utilised to enable their owner to reach out into the skies. The services of Sir Charles Parsons to astronomy provide an example that is still more recent; but, in this instance, early associations undoubtedly had much to do with his interest in this pursuit.

This point, of interest in a non-professional branch of science, need not be laboured. What we wish to convey is that the engineer of to-day commonly appears to be content with too near an horizon; he who has conquered the wide seas, to be content to remain at anchor; he who has given wings to man, to be content to stay earthbound. Astronomy, of course, is not the only science in which he can find enlargement of the mental horizon; even so seemingly remote a science as botany has something to show him. The armoured hose, for example, was anticipated æons ago in the common rhubarb, the thin-walled main stem vessels of which are reinforced by helically-wound strands of cellulose, thus securing strength while economising in material. Again, the lately-developed practice of humidity control is but an imperfect adaptation of those contrivances in the leaves of plants, known as stomata. These few illustrations are not intended as suggestions that the engineer, when he studies a science or an art, should be continually looking for analogies to his own work. They may serve, however, as an indication that the paths parallel to those of even the confirmed specialist may be bordered with attractive and possibly fruitful growths.

Not every engineer can hope to attain this wider outlook, but surely the influence of the most conventional training should be capable of a broader utilisation than is represented by the mere factual knowledge accumulated in the course of it. The properly trained engineer should be able to separate faulty data from those that are reliable; to analyse a situation and strip it of redundancies and excrescences, and to synthesise from material that is unrelated or even apparently discordant. With such accomplishments, he ought to be of greater service than he is on public bodies, but he cannot expect to be so employed until he has demonstrated indubitably the possession of some grasp of current problems and some acquaintance with modern thought and aspirations. Engineers have recreated nearly every ancient industry, they have added immeasurably to almost every amenity possessed by man to-day, but they do not seem to regard themselves as qualified to take a share in either public or private administration; and the public, taking them at their own valuation, accept as leaders, advisers and guides, members of other learned professions.

NOTES.

ASSISTANCE FOR THE COAL INDUSTRY.

A WHITE Paper, which was issued by the Mines Department last week, gives details of a compensation scheme, which has been put forward by the Colliery Owners Central Council. This, it is hoped, will help to prevent collieries from becoming derelict through war losses by making a levy on all coal sold for home consumption or export. The Government have approved the scheme, which will come into force at the beginning of the year. The levy will be recoverable in the price charged to the consumer, and is not expected to exceed 4*d*. a ton. In any event, the maximum will be 6*d*. a ton. Compensation will be at a flat rate not exceeding 3*s*. 6*d*. per ton, and its payment will be conditional on the maintenance of the colliery "in a condition to produce not less than its basis tonnage within a reasonable time, unless such failure is due to enemy action." The basis tonnage will be the sale of coal in 1939, and the compensation will be paid on the difference between the actual sales and what those sales would have been if the colliery had maintained its 1939 proportion of the total coal trade of the country. The scheme is related to the share of each undertaking in the total trade available, and not to its individual profit or loss. As the Mines Department points out, there is a grave danger under existing conditions of collieries that have had to close becoming derelict. Among the uncertainties of war it would be imprudent to allow any considerable number of producing units to be prematurely abandoned.

THE WAR DAMAGE BILL.

The War Damage Bill, which was formally introduced in the House of Commons last week, is an attempt to fill a gap in a scheme which, while providing the citizen with food and shelter and compensating him for loss of life or limb due to enemy action, did little or nothing to assist him in repairing any damage to his property. The idea of effecting this assistance by some form of insurance was scouted at the beginning of the war, and that it was not until it was found that the destruction of property by hostile air attack was less than might have been expected that a change of view occurred. Actually, since the measure was promised, rather over two months ago, the enemy has become much more active in the air. We are glad to see, however, that has not caused the abandonment of a very necessary piece of legislation, though it may have brought about an increase in the premiums payable. Briefly, the Bill provides for the compulsory insurance of all buildings and other immovable property. The necessary funds for compensating for the damage caused will be built up by contributions from the owners of property at the rate of 2*s*. in the pound on the net Schedule A value (or net rateable value) each year for five years. These contributions will be in respect of war damage during the two years from the outbreak of war until August 31, 1941. If the total compensation payable exceeds 200,000,000*l*., the Exchequer will meet the excess up to another 200,000,000*l*. If it exceeds a total of 400,000,000*l*., half the excess will be met by the Exchequer and half by increasing the premiums. The payment of compensation will be controlled by a War Damage Commission and, generally speaking, will be deferred until after the war. There are, however, several exceptions to this rule. In addition, all movable assets of business undertakings will be compulsorily insurable at the rate of 30*s*. per cent. for the period from September 3, 1939, to September 30, 1941, and personal chattels may also be insured at the same rate up to a total value of 1,500*l*. per person, plus a sum not exceeding 500*l*. for a motor car. A scheme like this, which affects almost every inhabitant of the country in a greater or less degree could not, of course, be prepared without touching a number of existing interests. The Bill therefore provides for apportioning the contribution payable where several persons have interests in one property, for determining the compensation payable on the basis either of the value at March 31, 1939, or of "the cost of works," and for relieving certain institutions from payments. All three schemes are retrospective in the sense that compensation will be payable to those who have already suffered. The principle is sound, but some amendments in detail will be required.

TEMPORARY COMMISSIONS IN THE NAVY.

The Admiralty announce that the large numbers of additional officers required for the expanding naval forces of the country will be mainly obtained by granting temporary commissions to those already enrolled as ratings. Persons who desire to enrol in the Navy with a view to earning commissions by service should, if they are within an age group registered for national service, express a preference for the Navy, if they have not already done so. If they are over the age of 18, and the date on which their age group is required to register has not been announced, they may register as wishing to join the Royal Navy or the Royal Marines, but their subsequent acceptance will depend on the general recruiting programme and the fact that in some of the small branches there may be a long waiting list. Once the volunteer has registered, he need take no further action unless he becomes liable to register under the National Service (Armed Forces) Acts. In that event, he must register under the Act and express his preference for naval and marine service. Ratings are eligible to be earmarked as suitable for commissioned rank at an early date of their training, and, if recommended by their commanding officer, can normally appear before a Selection Board after three months' service at sea. Special arrangements exist for the selection —prior to entering the Navy—of candidates for pilot and observer duties in the Fleet Air Arm. Although entry in the first place is in the rating of Naval Airman 2nd Class, all those who satisfactorily complete their courses, and are recommended, receive commissions in the Air Branch of the Royal Naval Volunteer Reserve. In addition, a number of appointments requiring special qualifications or experience will continue to be filled by the rating as commissioned officers of men from civil life. For these appointments, applications are invited from officers of the Merchant Navy not exceeding 55 years of age, who hold Board of Trade certificates as Master or First Mate, and who are not at present employed at sea; from qualified electrical or mechanical engineers who are required for commissions in the electrical or engineer branch of the Royal Naval Volunteer Reserve; from men under the age of 28, with at least 100 hours solo flying experience, who are required as civilian air pilots; from men between the ages of 28 and 45, with at least 50 hours solo flying experience, who are required for employment in training squadrons, and from men between 35 and 45 years of age with considerable administrative or organising experiences, who are required for service in the Special Branch of the Royal Naval Volunteer Reserve. Full information about all the foregoing appointments can be obtained from the Secretary of the Admiralty (C.W. Branch), Whitehall, London, S.W.1. Applicants should give full details, such as age, previous service, experience and qualifications in civil life, to save unnecessary correspondence. Applicants cannot be dealt with in person until they are invited to appear before a selection board.

THE JUNIOR INSTITUTION OF ENGINEERS.

The exigencies of war involved some departures from precedent when the inaugural meeting of the 60th session of the Junior Institution of Engineers was held on December 14. Apart, however, from the air of novelty about a Saturday afternoon meeting in the Institution's rooms at 39, Victoria-street, S.W.1, in place of the customary Friday evening function in the hall of the Royal Society, and the attendance of the retiring President, Sir Charles Bressey, in Home Guard uniform, the proceedings were true to the tradition of informality that is characteristic of "the Juniors." The introductory business over, Sir Charles proceeded to present the medals and other awards for papers delivered during the previous session, the list of which was given on page 402, *ante*. A vote of thanks to Sir Charles for his two-years' tenure of office was proposed by Mr. J. W. Stenson (chairman of the Institution), seconded by Mr. N. L. Ablett (vice-chairman), and carried by acclamation. Sir Charles then inducted as his successor the Rt. Hon. Viscount Falmouth, who delivered a short address in which he surveyed the functions of the engineer in time of war, emphasising the paramount importance of research in both war and peace, and the need for more attention to possible simplifications of design as aids to more efficient production. Under war conditions, Lord Falmouth concluded, the Services should be content with something less than a 100-per cent. solution of a given problem. It would be better, in many cases, to accept an 85-per cent. solution rather than wait for a better result later; weeks and months, in war, had a habit of becoming decisive factors. A vote of thanks to Lord Falmouth, proposed by Mr. W. A. Tookey (vice-president) and seconded by Mr. L. P. Walter (vice-chairman), concluded the proceedings.

THE ENEMY'S OIL SUPPLIES.

The intensification of the campaigns in western Egypt and in Albania emphasises the truth that one of the most important factors in our success and the enemy's failure will be the amount and distribution of available oil supplies. From that point of view, a recent statement by the Minister of Economic Warfare is encouraging. In his opinion, Germany would be in difficulties in a few months, if the Navy retained its control of the Eastern Mediterranean and the Air Force continued to bomb their oil stocks, plants and refineries. It was now essential, he said, for the Germans to have a movable quantity of oil over and above which might be called a distributional minimum. Failing that, any unexpected calls, such as, for example, might be needed to quell disaffection in Denmark or to come to the rescue of Italy, would land them in difficulties. There was good evidence that the margin between the enemy's total supplies and that distributional minimum was decreasing and that within a few months it would be awkwardly narrow. From Germany's point of view, imports from Russia and Roumania had been disappointing and, to improve them, better transport facilities would be required. Italy, it was believed, had now nearly exhausted her own stocks and would soon have to ask Germany for help.

PROTECTION OF ELECTRIC CABLES FROM CORROSION.

A remedy for preventing the corrosion of electric cables by electrolysis is described in the current issue of the *Post Office Electrical Engineers' Journal*. Such corrosion may be due to small currents arising from natural causes, which are propagated between areas of varying potential within the cable network, or much more rapidly by the passage, to and from the cables, of large stray currents from direct-current traction systems. A third cause is electro-chemical action between the soil and metallic conduit. To overcome this trouble, the sheath of the cable is broken up by cutting gaps 0·5 in. long in the lead. Each gap is then filled with adhesive tape to the level of the sheathing. The sheathing in turn is cleaned and roughened, and is then wrapped for a length of about 10 in. with evenly lapped layers of rubber tape. The tape in the gap and that over the sheath are applied under tension and in one length per layer. This allows a split rubber sleeve, which is placed over both gap and sheath, to seat evenly with a space of 0·25 in. between the faces. A bolted metal coupling, which is painted inside and out, is fitted over the rubber sleeve and has spacing washers between the flanges, so that the whole fitting makes a watertight joint. It is claimed that complete insulation of the two sides of such gaps is maintained by the removal of any bonding, by the re-arrangement of any branching cables, and by the insulation of the brackets with special tape. In this way the sheath of a length of cable liable to attack can be isolated electrically. It is understood that many of these gaps have been fitted in the London area, where sheath currents of as much as 2 amperes are encountered in the vicinity of traction systems. In such cases, the potential difference between cable and earth ranges from 30 mV to 150 mV (positive), while several hundred milliampere are not uncommon in sheaths of cables in earthenware conduit which are in physical contact with others in isolated sections of metallic conduit.

THE INSTITUTION OF MECHANICAL ENGINEERS.

AN ordinary general meeting of the Institution of Mechanical Engineers was held at Storey's Gate, St. James's Park, Westminster, on Friday, December 13, the chair being occupied by the President, Mr. Asa Binns.

HIGH-PRESSURE STEAM GENERATION.

The meeting was convened for the reading and discussion of a paper by Mr. R. F. Davis, M.Sc. (Eng.) entitled "The Physical Aspect of Steam Generation at High Pressures and the Problem of Steam Contamination." The paper itself will be reprinted in abridged form in a subsequent issue, but a brief summary is as follows: The constitution and physical properties of boiler water are investigated with reference to operating pressure, and it is shown that, while nuclear boiling is the normal mode of evaporation, film boiling may take place under certain conditions. The size of the generated steam bubbles is related to heating surface characteristics and working pressure, and, during migration from this surface to the free water level, the bubbles experience rapid growth at low pressures, but only negligible growth at high pressures. Bubble size affects circulation. At high pressure the steam bubbles are very small and salts in the boiler water tend to inhibit coalescence. On disruption in the steam space, small bubbles throw up minute drops of water, the height of projection of which depends on the pressure and rate of steam release. The drops, becoming entrained with the steam at a certain critical rating, cause wet steam, which is also caused by foaming, this phenomenon being found to depend on the physical state of the suspended solids in the boiler water. The paper concludes with a discussion on mechanical priming and methods of preventing steam contamination from moisture and solids.

As Mr. Davis was delayed in reaching the meeting, the paper was read in abstract by Mr. C. W. Taffs, M.Sc. (Eng.), assistant secretary, though Mr. Davis was present to hear the latter part of the discussion. The President, after remarking that the paper dealt with a subject of ever-increasing importance, called upon Major William Gregson, M.Sc., chairman of the Steam Group, to open the discussion. Major Gregson said that the large high-pressure water-tube boiler had been mainly dealt with, but priming, foaming and carry-over were even more prevalent in other types of boiler in industrial, locomotive and marine practice. He thought the effect of circulation on these working phenomena might have been more fully stressed. Although an opinion in favour of unheated downcomers had been expressed, the conditions governing the progress of steam bubbles to the free water level were correctly visualised only if a plain tank, or so forth, were considered, but in a boiler, movement of the bubbles in the water was upset by the definite circulation usually obtaining in the tubes. He thought some of the arguments in the paper applied only to water-tube boilers. They could hardly apply to the locomotive boiler in which the evaporation at the top of the firebox was so high that if these arguments held good the firebox would not stand at all. Actually, however, a locomotive boiler survived very well. The accepted condition of the boiler water was, in present practice, for it to be slightly alkaline, and he thought that the author's comments on water conditions perhaps laid too much emphasis on perfect feed water, the use of which might involve such troubles as erosion. On the question of priming, he would like to mention a paper read by Eng. Rear-Admiral Dight, R.N., before the Institution of Naval Architects.*

Mr. R. E. Zoller queried the statement that nuclear boiling could not be obtained on an absolutely plain surface, as the bubble would be infinitely small and the superheating of the water infinitely high. Apart from the impracticability of obtaining such a surface, he argued that infinite superheat could never be reached since, when the critical pressure was reached, the internal pressure and internal pressure of the bubble would be the same. It appeared to be a large assumption that the coefficient of heat transfer between the steam and the bubble was constant. In Jacobs's paper several values, between 1,600 B.Th.U. and 5,600 B.Th.U. per square foot per hour per deg. F. were given. He, himself, thought the transfer rate would vary a good deal with the pressure. At high pressures there was a lower relative velocity between the steam bubble and the water, there was a higher viscosity and specific heat and a smaller bubble size, and these tended to make the transfer higher. There was, however, no practice to help. He thought the illustrations given of bubbles in the paper required modification when the rate of formation was such that the bubbles touched each other.

Mr. S. A. Robertson congratulated the author on his analysis of bubble conditions. The study was, however, still in its initial stage, and much remained to be done. He then referred to and exhibited some diagrams given in the paper he and Mr. Lewis had presented recently,* in illustration of bubble formation. On the subject of film boiling, he suggested that Nukiyama's results be received with caution, as they were derived from heating a fine platinum wire: an entirely different set of conditions from heating a surface like a boiler tube. Film boiling might occur in a tube when no circulation existed and the resulting blanket of steam might cause the steel to be excessively heated. Good circulation must, therefore, be arranged for, and he agreed with the author's conclusion that unheated downcomers were desirable. On the subject of steam quality, he was of opinion that control must be in the tube and not in the drum, and the simplest method seemed to him to be to use downcomer tubes of the Perkins-Field type, in which the steam flow could be calculated with reasonable certainty and controlled by fixing the proportions of the tube.

Mr. G. W. Hewson, speaking as a chemist responsible for the condition of the water in several power stations, paid a tribute to the utility of the paper. The illustration given of the bend of a superheater tube choked by carry-over deposits was illuminating, but there was also the danger of corrosion at such points by water lodging there and absorbing oxygen and CO_2 when the boiler was laid off and the interior open to the atmosphere. Every part of a boiler should be designed so that it could be completely drained when not in use. Regarding the dissolved solids permissible in boiler water, he would suggest much lower figures than those given by the author. In two installations with which he was connected, the solids were below 300 parts per million. In one of these plants the boilers had worked for 12 years without serious trouble, and in the other for seven years. The figures quoted in the paper were much in excess of those of successful modern practice, and looked like the results of treating the water with chemicals in excess of absolute need. As to steam contamination, he had found that working with the solid ratio he had just mentioned and with a feed make-up of under 3 per cent., steam contamination had been practically eliminated and there was very little trouble from foam. He thought if a *p*H recorder could be designed, it would enable a finger to be laid on the cause of contamination in the feed water.

The final speaker in the discussion was Dr. R. Pendennis Wallis, who observed that, in connection with the formation of steam bubbles, it was necessary to see whether the particular part of the boiler being considered was operating under conditions similar to those laid down in the pertinent part of the paper. The majority of the results given were applicable to the vertical-tube type of boiler and care must be exercised before applying them to boilers having horizontal tubes. He was interested in the change of shape of the bubble, from spherical to lens or umbrella-shape, and later on, if the height of the water column were large, to a spherical shape again. The change seemed to be connected with velocity and not momentum, as the author would appear to suggest, and it would be of interest to have some further explanation.

The meeting then terminated, Mr. Binns pointing out that, as Mr. Davis had not been present throughout, he would reply in writing when he had read the remarks of the first three speakers.

* See ENGINEERING, vol. 141, page 409 (1936).

* See ENGINEERING, vol. 149, page 291 (1940).

LETTER TO THE EDITOR.

FIFTY YEARS OF PRESSURE SCAVENGING.

TO THE EDITOR OF ENGINEERING.

SIR,—We have read with considerable interest Mr. Jackson's letter of November 13, appearing in your issue of November 29, on page 436, and feel that he has failed to grasp the significance of the statements made in his previous letter. In his second contribution, he has made a convenient summary at the end of the letter, regarding his views on the subject. As expressed, they appear to apply to the respective methods of pressure charging generally, and not specifically as his own personal experience.

He states:—"(1) With turbo charging there is an improvement in fuel economy throughout the full range of loads." That statement, admittedly, applies to the engines with which he has had experience, but it does not apply generally to that method of pressure charging.

Mr. Jackson refers to curves illustrated in the January, 1938, issue of *The Oil Engine*. If he had examined them closely, he would have found an instance there of an exhaust turbo-charged engine which gave a lower fuel consumption when running with atmospheric induction than when pressure charged, and, furthermore, our own experience goes to confirm that with an engine operating to the best advantage with atmospheric induction, there is no appreciable change in thermal efficiency when operating pressure charged at loads from and below its normal atmospheric-induction rating. This confirms our impression that if his engines had been operating to the best advantage under atmospheric-induction conditions, there would have been no appreciable change in fuel consumption at fractional loads when operating pressure charged.

He then goes on to state:—"(2) With motor-driven charging, there is an increase in consumption at any load when the blower is in operation." Here, again, he may, in his experiments, have found this to be the case, but because he experienced such an increase in consumption, it does not mean that it is a general feature of the method, but it is peculiar to his own sets. The statement he makes should, therefore, apply to them alone, and not to the system generally.

"(3) Increase in power with turbo-charging exceeds the increase with engine-driven blower charging." Here, again, he is expressing his own experience, whereas there are many instances of engines operating on the Hamilton pressure-scavenging method developing a 50 per cent. increase in output as a 12-hour rating, plus 10 per cent. overload for one hour.

"(4) The cost of equipment for blower charging is much less than for turbo charging." In this case, we are in entire agreement with Mr. Jackson.

Yours faithfully,
For CROSSLEY-PREMIER ENGINES, LIMITED,
A. CYRIL YEATES,
Chief Engineer.

Sandiacre,
Near Nottingham.
December 13, 1940.

THE LATE MR. JOHN BARR, C.B.E.

WE regret to record the death of Mr. John Barr, for many years one of the most prominent administrative heads of the British shipbuilding industry, at his home in Beckenham on December 10. Mr. Barr, who was in his eighty-second year, was associated for some 50 years with the Barrow shipyard of Messrs. Vickers-Armstrongs Limited, and possessed the unusual distinction of having been president of the Shipbuilding Employers' Federation for three successive years. Owing to failing health and the handicap of increasing deafness, he had been living in retirement since 1937, though, at the time of his death he was still a director of the Iron Trades Employers' Insurance Association and of National Shipbuilders' Security, Limited, and a member of the Council of the Federation of British Industries.

John Barr was a native of the small village of Kirkby-in-Furness, where he was born in 1859. His father was engaged in the local slate-quarrying industry, but John, after attending the Barrow Commercial School, elected to go to sea. After making a few voyages in a sailing vessel, however, he obtained a post in the commercial office of the Barrow Shipbuilding Company and remained with them and their successors, the Naval Construction and Armaments Company, Messrs. Vickers, Sons and Maxim, and Messrs. Vickers Limited, until 1923. He had been chief accountant for some time, when, in 1917, he was made a director of the last-mentioned company. In association with the late Sir James McKechnie, Mr. Barr was intimately concerned with the task of expanding the small yard of

the Barrow Shipbuilding Company into the immense undertaking which it subsequently became. Long and responsible as was his direct connection with Barrow, however, his more important work was done on behalf of the industry as a whole in the many conferences and committees of which he was a member from time to time.

During the war of 1914-18, he served on a number of committees concerned with labour questions, and represented the Shipbuilding Employers' Federation on the committee of inquiry appointed in 1917 to report to the Industrial Unrest Commission on the wage rates of skilled men employed on munitions work. It was for these services, in particular, that he was appointed a C.B.E. in 1920. His presidency of the Federation extended from 1924 to 1927, during which period he also served for two years as joint chairman of the committee which inquired into conditions in the shipbuilding industry, and the effects of foreign competition. The state of affairs which this inquiry disclosed made evident the need for closer co-ordination of effort between British shipbuilders, and when the Shipbuilding Conference was formed for that purpose, in 1928, Mr. Barr was appointed its Controller. He was also a director of Messrs. Vickers-Petters, Limited, until Messrs. Vickers Limited, disposed of their interest in the Petter oil-engine works at Ipswich.

WAR-TIME BUILDING CONSTRUCTION.

THE nine *Wartime Building Bulletins** which have already been issued by the Department of Scientific and Industrial Research consist of a series of studies of the economical use of materials for various types of building construction. In the latest *Bulletin*, No. 10, the whole field of war-time building, which, of course, presents a number of problems that do not arise in peace time, is brought under review and the broad general principles, which have resulted from the study, are made clear.

Among the more important of the new problems is air-raid protection. This means that the building must be constructed in such a manner that it suffers the minimum of damage from aerial bombs. The buildings and their roadways must also be inconspicuous from the air and shelter must be provided for the occupants. This shelter must be arranged so that the loss of working time can be kept to the minimum and loss of sleep avoided as far as possible. A second factor is that economy must be observed in the use of materials. The following are the main points for consideration at the start of a project: The available supply of suitable materials is liable to rapid change in war-time and it is necessary to make a reasonable balance in the use of materials when several are in short supply. The ideal would be a day-to-day "rate of exchange," quotation between the vital materials, but the machinery for fixing this, it is pointed out, does not exist and would be difficult to devise. The day-to-day fluctuations in supply and demand of materials are best met by fluidity in specifications and adaptability to permit alterations in specifications at any stage in the erection of a building. It is also desirable to ensure that specifications are modified where desirable to conform to site conditions. Powers to introduce variations, where wisely employed, have enabled useful economies to be made and works have been speeded up. Every encouragement, it is stated, should be given to all concerned to bring forward any helpful ideas, and contractors should certainly be given a hearing. In this way the danger of over-centralisation of control can be avoided.

The natural tendency is for everybody to regard their own particular job as more important than any other, and on jobs where materials are available, this attitude engenders a lavish use which is liable to result in works less favourably situated being held up, though these may be only slightly less important to the war effort. A planned economy in the use of materials is, however, not incompatible with speed in the erection of buildings. It would be untrue to state that any one method of construction is quicker than all others, and past experience shows that, with team work on the part of designers and contractors who have specialised in various methods, almost any of the well-tried systems of building can be organised to produce rapid construction. It is desirable to spread the work in such a way as to make use of the capacity of the various sections of the industry and, in this way, to avoid overloading any one section.

In brief, the *Bulletin* explains how to begin tackling these problems, and should serve to assist the designer in the preliminary stages of a war-time building project. It comprises notes on the concealment and the minimising of damage through air attack, which were contributed by the technical branches of the Ministry of Home Security. Some suggestions on how to start saving timber are given in a section written by the Forest Products Research Laboratory. Information about economy in the use of other materials is given in the earlier bulletins, though slight modifications are made to the factory type designs in structural steelwork (*Bulletins* Nos. 1 and 4) to include the recent recommendations made by the Research and Experiment Branch of the Ministry of Home Security. These recommendations are based on the experience gained in recent air attacks.

Bulletin No. 11 deals with the precautions which must be taken when carrying out concreting and bricklaying in cold weather, as it is very important that there should be the least possible delay in urgent building work from this cause. Concreting and bricklaying, it is pointed out, are affected by cold weather in two principal ways: The mixes harden more slowly than at normal temperatures and the water in mortar or concrete mixes may freeze. What must be done to avoid trouble with concrete depends on how severe the conditions are, but for average winter weather simple precautions are enough. For instance, concreting should not be undertaken if the air temperature falls below certain limits and when concreting has stopped the concrete should be covered and protected. Aggregates and mixing plants will also need shelter.

For very urgent work, which has to be carried on regardless of extremes of weather, more drastic precautions are needed, and for these the Building Research Station has drawn largely on experience in Canada and the United States. For example, preheating of materials and the heating of equipment and formwork will be needed and after it is deposited concrete will often require to be heated during the initial stages of setting. Details of the equipment needed and the temperatures to be worked to are given in the *Bulletin*. A guide to the stripping of formwork is also given, and notes on the use of calcium chloride are included. Brickwork must be treated in much the same way as concrete, but special precautions in mixing and using mortars are mentioned.

Each *Bulletin* is published at the price of 1*s*.

* See ENGINEERING, vol. 149, page 569 (1940) and page 25, *ante*, *et seq.*

ORGANISATION IN INSTRUMENT MAKING.

THE great extension in the industrial use of electric power has led to a corresponding expansion in the manufacture of electrical indicating and recording instruments. This has become a highly competitive section of the electrical industry in recent years and, as the quantities required of a given design may vary considerably within a comparatively short period, there is ample scope for careful organisation in both design and manufacture. Some of the general principles involved, and the methods of control adopted, were discussed by Mr. G. A. Cheetham, M.I.E.E., in a paper on "Some Experiences in Organising the Design and Manufacture of Small Engineering Apparatus," read on December 14 at a meeting of the Manchester Association of Engineers.

Mr. Cheetham defined ideal industrial organisation as "the art of ensuring that the correct personnel and material meet at the correct time at all stages in the manufacture, and that the operations are all performed in the most efficient manner." He placed personnel first in importance, and emphasised the value of maintaining an experimental laboratory for work of this kind, and arranging that the junior engineering staff should pass through it before promotion to senior positions. The laboratory should be in charge of a good engineer, who should maintain continual contact with the selling organisation and with users of apparatus. When a rough mechanical design is complete, a model instrument should be designed, and constructed by a section of skilled craftsmen retained for such work. After testing, and modification if necessary, it should be passed to the manufacturing department for processing—preferably, he suggested, under the direction of a committee consisting of the tool engineer as chairman, a process engineer, designer, draughtsman, efficiency engineer, and the chief inspector. The various foremen should be called into consultation when the particular parts that they are to make are under discussion.

The two main divisions of the manufacturing personnel, Mr. Cheetham continued, were those concerned, respectively, with material and equipment, and with the details of manufacture. The first group should possess "a high degree of organising ability and a reverence for tidiness in method and practice," without being slaves to system for its own sake. The second group should be freed, as far as practicable, from the details of the system, so as to be able to direct their entire effort towards producing the components in the best possible manner. The efficiency engineer's duty was to see that the total labour cost was kept within the estimate, subject to no one item being abnormally in error. The method suggested by Mr. Cheetham was to plot the cumulative costs against the cumulative estimate, so that the progress of a new product would be apparent at a glance; and he pointed out that, if the abscissæ of such a curve showed the total of operations to be performed in each section, the rate of growth of the curve would also indicate the rates at which process prices were fixed.

After discussing the functions and necessary qualifications of the inspecting staff, commenting favourably on the value of motion study, and discussing alternative methods of regulating stocks of materials, Mr. Cheetham proceeded to describe the scheme of production control employed in the manufacture with which he was personally concerned. It might not be suited to many other factories, he said, and, theoretically, it was unsound in one respect; but it had been found to work satisfactorily, at a cost that was very much less than would have been incurred with a theoretically perfect system. To quote his own words: "All orders are made out on cards, those cards which represent planned orders being distinct in appearance from those representing small-quantity orders. Each machining section of the works is provided with a rack, with a number of pockets similar to those used for time-clock cards. Vertically, each row of compartments represents numbered machines on that section and is numbered accordingly. All cards received are filed in one or two compartments marked 'orders waiting.' The planned orders are marked with the time they should enter and leave each particular section, and in planning an interval is left between each group of operations to cover any delay which may occur in completing the particular operation. In each section in the planning a certain number of machines are allocated for the planned product.

"In practice, preference is given to the small-quantity orders, and it is the duty of the production engineer in the section to have all his small-quantity orders in work or completed. This is shown by moving each card into the compartment numbered for a particular machine which is labelled 'in work.' When all small-quantity orders are in work or cleared, the planned orders are passed on to the machine. Since the planned orders are marked with the time they should be fed on to a particular section and the time they should be completed, and since they are filed in time sequence, it is possible at any moment to determine the number of hours late the plan is running. From experience it is known that if this exceeds a certain number of hours, there is danger of affecting assembly, and in consequence operators are moved, or overtime worked, to reduce this lateness within the tolerance margin. The theoretical imperfection mentioned above is that the programme always runs late, but since this is controlled it is unimportant, and against this imperfection must be set the time taken to plan all small-quantity orders, which would be considerable. It also allows the ratefixer to use discretion in fixing individual prices for extremely short operations.

"All material is fed directly to the machines from the control stores, and to avoid delay a signalling system is instituted on each machine. Since the operator knows the piece-work price, it is his or her responsibility to put up a signal a given time before a job will be completed on the machine. Immediately this signal is made on the machine, the control storekeeper issues the next job to the machine, stamping the card with the time it was issued. A further signal is made by the operator immediately the first job is completed, when the control storekeeper arranges for its removal. Tools and drawings are issued to the operator with the job, the control engineer requisitioning from the tool stores the appropriate drawings and tools some time before the job is issued. This is carried out by passing a duplicate of the control-board tag to the tool stores. This contains all the necessary information. When any job is completed, the card is removed into the compartment marked 'inspection,' and finally, after approval by the inspection department, both material and the order card are transferred to the next section. A physical glance at the control board will show the number of machines in work at any one time and whether one or two jobs are at the machine. The number of orders waiting is also clearly visible." No doubt, Mr. Cheetham added, the scheme would be criticised severely by the advocates of scientific management; but it did work satisfactorily, and at a low cost. He believed it to be novel, in that control of the whole product could be maintained by observations made on only a portion of the work.

THE RAND MEDAL OF THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS.—The first award of the Charles F. Rand Memorial Medal of the American Institute of Mining and Metallurgical Engineers has been made to Mr. R. C. Stanley, chairman of the board and president of the International Nickel Company of Canada, Limited.

SOLVENT EXTRACTION OF OIL.

In normal times the extraction of oils and fats, both animal and vegetable, by means of solvents, is an industry which has progressed steadily for many years, being applied to such diverse materials as oil-seeds, whale meat, used bleaching materials, such as fuller's earth, etc. In war time the industry assumes greater importance, and it is applied to the recovery from materials of oils and fats which might otherwise be wasted. The greater demand for edible oils and fats in war-time arises from two principal causes; in the first place, restricted supplies of butter create a larger demand for margarine, which is made from the higher grades of these oils and fats; secondly, glycerine, also derived from them, is required in much larger quantities for the manufacture of explosives. As most of these oils and fats are imported, the treatment of any waste material containing them becomes of greater significance in war-time. Apart from the recovery of oil from waste materials, a greater yield of oil directly from the oil-seeds themselves is obtained when the solvent-extraction process is applied to them instead of the crushing method, for the former process leaves less than 1 per cent. of oil in the residue as compared with about 10 per cent. with the crushing method.

Until a few years ago, plant manufacturers constructed only one type of plant for solvent extraction, irrespective of the nature of the material to be dealt with, so that in many cases the solvent-extraction method of recovering oil was thought to be a failure, though actually the fault lay in the design of the plant. More recently engineers have gradually evolved different designs of plant to suit all the various materials from which oil can be extracted with solvents. For example, some materials are best dealt with in a vertical cylindrical vessel, which may or may not be provided with agitators. For other materials a horizontal vessel is more efficient; this may or may not have stirring gear, and in some cases the vessel is made to rotate. The question of the action of the solvent on the metal of the plant has also to be considered. In war-time, there may be come scarcity of petroleum solvents, since these are imported, and other solvents, such as carbon bisulphide, which can be produced cheaply in this country, may take their place. Carbon bisulphide, in the pure state, has no appreciable action on the iron or steel of the plant, but the commercial grades of this solvent frequently contain impurities which bring about an energetic action between the solvent and the metal, and instances are on record in which this action has led to the ignition of the solvent. Thus, a plant previously run on benzine, which has no action on iron or steel, would need to be lined throughout with a non-ferrous metal alloy prior to the adoption of industrial carbon bisulphide. When carbon tetrachloride is employed, it is preferable to have lead-lined plant, as this solvent attacks both ferrous and copper materials, especially in the presence of water, which is unavoidable in commercial extraction processes. The physical properties of the solvent used are also of importance in the economy of the process, as a study of the following data will show. Average figures for the chief physical characteristics of three typical solvents are given in Table I:—

Table I.

Solvent.	Specific Gravity.	Boiling Point.	Specific Heat.	Latent Heat of Vaporisation.
		Deg. C.		Cals. per Gramme.
Petroleum ether	0·75	112	0·50	80
Carbon tetrachloride ..	1·63	76	0·21	46
Carbon bisulphide ..	1·29	46	0·16	80

In bringing a solvent into contact with a material from which oil is to be extracted it is the volume of the solvent that counts, not the specific gravity. Therefore, from the above figures, it will be seen that a given mass of petroleum ether will have over twice the volume of, and will go more than twice as far in the processing, as a similar mass of carbon tetrachloride. The boiling point, specific heat and latent heat also have a direct bearing on the quantity of steam used in the plant for distilling the solvent from the extracted oil and for expelling the solvent from the residue. The question of which solvent to use is not only of technical efficiency only, for in some areas the use of inflammable solvents would be prohibited, and in other cases the use of such solvents would mean a considerable increase in insurance premiums. In such instances a non-flammable solvent may be used, such as trichlorethylene or carbon tetrachloride; in others, benzine or petroleum ether may be employed.

The general layout of one of the solvent extraction plants made by Messrs. George Scott and Son (London), Limited, Artillery House, Artillery-row, London, S.W.1, is shown in Figs. 1 and 2, on this page. A feature of this plant is that the agitators of the two extracting vessels are driven from below, so leaving more space at the top of the vessels for feeding from the hoppers immediately overhead. One relatively small motor serves to drive the agitators and also the rotary pumps for conveying solvent and extracted oil. The material from which the oil is to be extracted passes from the feed hoppers into the extractors, and a suitable quantity of solvent is then run in from the tank above. The method of securing intimate contact between the solvent and the material varies with the nature of the latter. Some materials may be efficiently treated by simply stirring up with the solvent; others require warm solvent to be pumped continuously through the vessel. After a time, the resulting oil and solvent mixture is passed through a filter into the still on the right, in which the solvent is evaporated from the oil, the condensed solvent being used repeatedly and the separated oil being pumped to store tanks. The still is capable of working continuously, and it may be operated either by means of open steam, by heating coils or by hot plates, and worked under vacuum when necessary.

SOLVENT EXTRACTION OF OIL.

Fig.1.

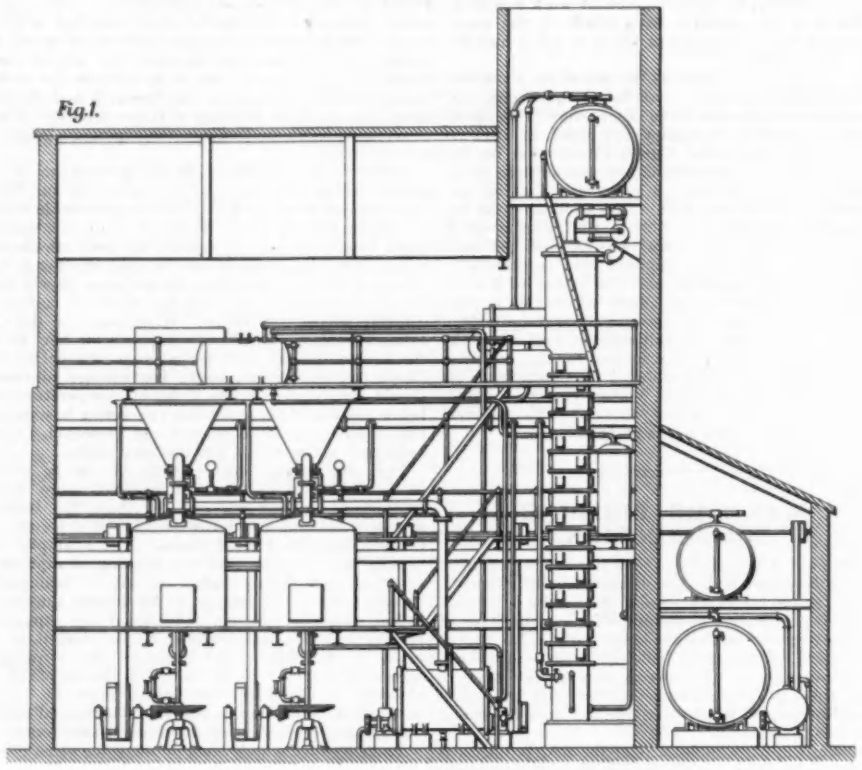
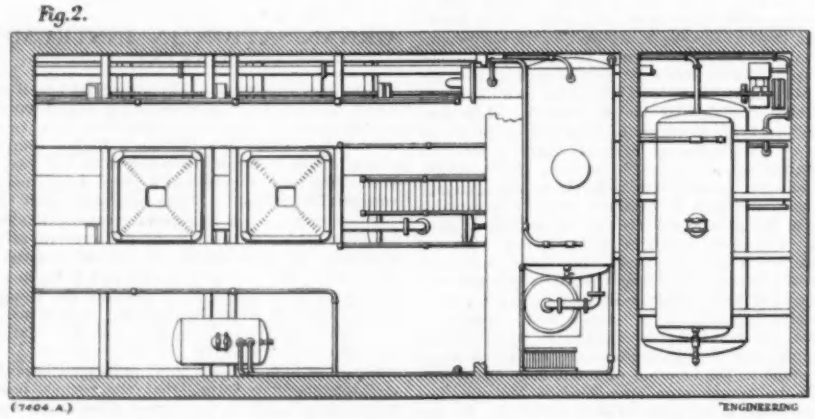


Fig.2.



Extracting vessels are normally provided with some means of heating the oily material to facilitate the liberation of the oil; they usually have either a steam jacket or a coil, and, in addition, fittings for open steam are often provided in the base of the vessel. The open steam is blown upwards through the residue to expel the absorbed solvent, the steam and solvent being separated in the still if the solvent is soluble in water, or by a water-separator if the solvent is insoluble in water. When open steam is liable to damage the de-oiled material, heat is applied through the steam jacket or coil and the extractor is often operated under reduced pressure to volatilise the solvent more rapidly. Safety valves are fitted at all necessary points.

The extraction units of a complete solvent extraction plant arranged for handling oil-seeds, and built by Messrs. Rose, Downs and Thompson, Limited, Old Foundry, Hull, are shown in Fig. 3, opposite. The extracting vessels are seen on the erecting floor while undergoing tests at the makers' works. In this plant, oil-seeds are conveyed directly from the hold of a ship, by means of an elevator, on to an automatic weighing machine, and thence to a magnetic separator to eliminate tramp iron. The material is then passed through screens to remove other foreign matter, and is finally conveyed to silos. A main elevator in the silo building delivers the seeds to a band conveyor at the top of the silos, arranged so that they can be diverted to any required silo. Similar band conveyors are provided at the base of the silos, and by these conveyors seed can be removed from any particular silo and conveyed to the grinding department. The type of grinding machinery used in converting oil-seeds and kernels to meal has already been described in our columns.*

The extractors seen in Fig. 3 consist of steel vessels, of the vertical type, 6 ft. 9 in. in diameter by 7 ft. high, and fitted with agitating gear. Over each pair of extractors is arranged a sheet-steel bin which holds

* See Engineering, vol. 132, page 481 (1931).

SOLVENT EXTRACTION OF OIL.

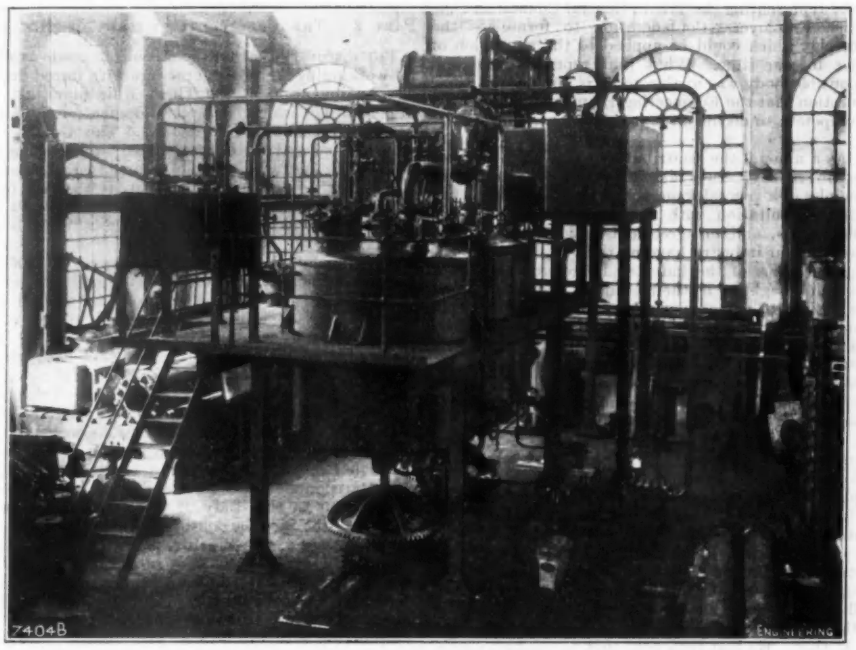


FIG. 3. EXTRACTION UNITS OF SOLVENT EXTRACTION PLANT.

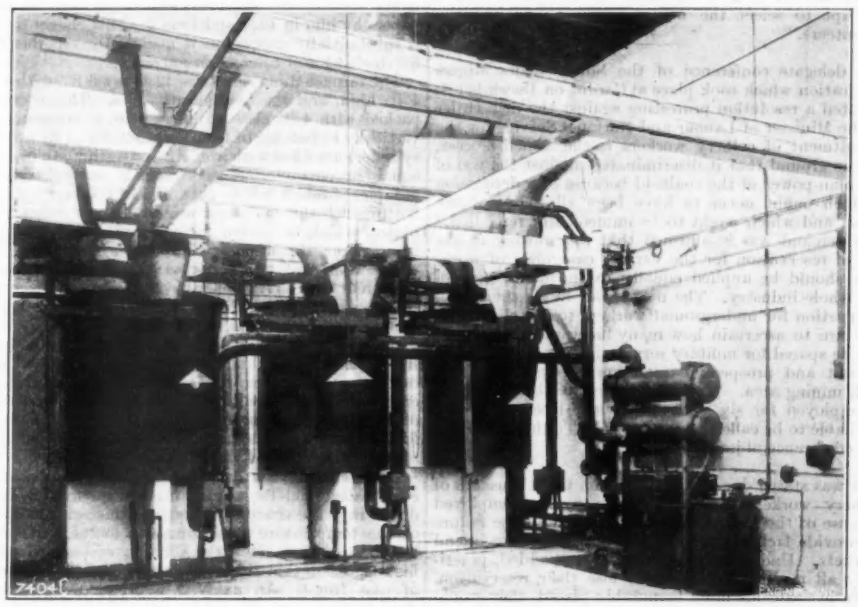


FIG. 4. SOLVENT-RECOVERY PLANT.

the correct amount of material to charge one extractor, a double outlet and steel swing door being fitted at the base of the bin. At the top of each extractor is a wide filling aperture, which, after the vessel is charged with material, is closed by a steel hinged lid having packing material at the edges to form a vapour-tight joint; the lid is arranged for quick closing by means of a screw clamp. When the filled extractor is closed, a valve, which controls the pipe-line connections between the extractor and an absorber apparatus, is opened. Mixed solvent is then run by gravity, or is pumped, from the solvent tank, through a tubular heater, to warm up the solvent, upwards through the base of the extractor. This operation causes displacement of air in the extractor, and the air travels along the pipe lines, pushing in front of it any solvent vapours left in the lines, so that they are caught by the absorber. A sight glass in front of the extractor shows the operator when sufficient solvent is in the vessel. The temperature of the solvent, while in contact with the oily material, is maintained at the desired value by a closed steam coil in the base of the vessel. The solvent used for the preliminary treatment of the material, is a mixture of solvent and oil from a previous batch, but the oil content is generally low, and it is more economical to use it again on a material relatively high in oil content than to distil it. When the mixed solvent has been in contact with the material for a few minutes it is drained from the extractor into a filter to remove any solid matter before proceeding to the distilling columns. Fresh solvent is next run into the extractor through an aperture at the top, and is allowed to remain in contact for a short time. If this used solvent is rich in oil when it leaves the extractor, it may go through the filter to the stills, but if not very high in oil content it is pumped to the mixed-solvent tank to be used again on fresh material. In most cases solvent is put through the extractor until it shows no trace of oil. In testing for this, a piece of filter-paper is immersed in the solvent, which quickly evaporates, leaving an oily stain if any oil is present. When the extractor is finally drained of solvent, the agitating gear is started up and steam is blown upwards through the material from a perforated coil in the base. This quickly liberates any residual solvent, which, mixed with water vapour, is led off to a brass-tubed condenser, where the solvent is condensed and pumped to a fresh-solvent tank. If the solvent used is soluble in water to any great extent, this solvent-water mixture must, of course, be distilled. The steaming and agitating of the de-oiled material is continued until it is practically free from solvent, an inspection of the condensate from the condenser determining when this point is reached. The material is then ready to be discharged through a wide outlet in the base of the vessel on to a conveyor. Normally, each extractor is operated alternately, so avoiding simultaneous heavy demands for steam and solvent, as one is steaming off while the other is extracting. It is quite possible to extract tne whole of the oil from the material, but the very long period necessary to bring out this residual oil renders its removal uneconomical.

The high cost of solvents, particularly in war-time, renders their recovery after use a matter of prime importance, and in all extraction plants the bulk of the used solvent is recovered by the stills and condensers. There remains, however, a certain proportion which goes to waste, some of which cannot be avoided. For example, a plant in extracting oil from 100 tons of oil-seeds may lose from 300 lb. to 400 lb. of solvent in the extracted meal in spite of efficient steaming, and a similar amount in the extracted oil, unless the latter is subjected to special heat and vacuum treatment. Such losses of solvent can be regarded as unavoidable, but the losses in some plants are greater than appear at first sight possible, and are represented by the solvent vapours which escape into the atmosphere at various points of the factory. The filling and emptying of the extractors, the circulatory pumping, and variations in temperature may all cause leakage of solvent vapour. In a test made by Messrs. British Carbo Union, Limited, 16, Queen Anne's-gate, London, S.W.1, with one of their recovery plants at an extraction factory, the solvent-laden working atmosphere was drawn into one common pipe line, and led through a cooler to precipitate the bulk of the benzine, which was the solvent in use. The average volume of vapour and air leaving the cooler was 20,000 cub. ft. a day, having a concentration of 10·2 grammes of benzine per cubic foot, corresponding to a loss of about 450 lb. of benzine a day.

In a type of solvent-recovery plant made by Messrs. British Carbo Union, the solvent-laden atmosphere is drawn upwards into one of two adsorbers, which contain activated carbon. As the solvent is taken up by the carbon, allowing the air to pass through, heat is generated, and from thermometers placed in the carbon column at different heights, the progress of the adsorption can be noted. When the adsorber is nearly at saturation point, the incoming solvent-air mixture is switched over into the other adsorbing vessel, and the former is put under steam, at a pressure of from 30 lb. to 40 lb. per square inch. This preliminary heating is done by means of a steam coil, but after a certain time has elapsed and the carbon is moderately hot, open steam, also at low pressure, is passed into the vessel from the top. The steam and solvent vapours pass into the condenser, where the two are condensed together, being afterwards separated in a water separator. When all the solvent is driven out of the carbon, the open steam is shut off, and the steam passing through the heating coil is allowed to continue until the carbon is thoroughly dry. The drying is assisted by blowing air through the mass of carbon, the air afterwards passing away to atmosphere. As soon as the carbon is judged to be dry, the steam in the coil is shut off and the current of air continued so as to cool the mass quickly. This cooling process may be speeded up by passing cold water through the steam coil at the same time, and when the carbon has cooled down it is ready for its next charge of solvent. Hence plants of this nature can be operated continuously, one absorber being under steam while the other is taking up solvent.

A solvent-recovery plant by Messrs. Sutcliffe, Speakman and Company, Limited, Leigh, Lancs, is illustrated in Fig. 4, on this page. This plant has three carbon adsorbing vessels, connected to which are seen, overhead, the large diameter pipe system for conveying the solvent-laden vapours to the adsorbers. When the vapours coming to the adsorbers are hot, it is usual to insert a cooler at some point in the pipe system to cool the vapour before adsorption. The solvent-air mixture enters the adsorbers through the connecting chamber seen at the front of each vessel, being drawn through the carbon column by a suction fan, one of which is situated over each adsorber at the rear, each fan being operated separately by its own motor. The solvent-free air leaves the adsorber by the pipe in the top centre of each vessel and is discharged to atmosphere by the fan. When the solvent-charged carbon is steamed, the steam and solvent leave the adsorbers through the pipe line at their base, passing into the condensers on the right, the two vessels underneath being separators for the solvent and water mixture. A rotary pump conveys the separated solvent back to the solvent store tank for re-use.

LABOUR NOTES.

ACCORDING to the Ministry of Labour and National Service, the number of men and boys registered at employment exchanges in Great Britain as wholly unemployed at November 11 was 308,131, a reduction of 25,805 compared with October 14. Those registered as on short time, or otherwise temporarily suspended from work on the understanding that they were shortly to return to their former employment, numbered 96,577, about 60 per cent. of whom were miners; this was an increase of 952 compared with October 14. Those registered as unemployed casual workers, being persons who normally seek their livelihood by jobs of short duration, numbered 23,548, a reduction of 3,481. The corresponding figures for women and girls at November 11 were 295,110 wholly unemployed, 66,787 temporarily stopped, and 1,027 casuals; reductions of 6,385, 8,670, and 282, respectively. The number of women registered as evacuated on November 18 was 39,194, an increase of 1,034.

An analysis of the duration of unemployment of persons who were registered as applicants for unemployment benefit or allowances at November 25, showed that out of a total of 359,000 men, 154,000, or nearly 43 per cent., had been on the register for less than two weeks, and 191,000, or over 53 per cent., for less than four weeks. Compared with May 20, the number who had been on the register for 12 months or more was nearly halved and numbered 54,000, of whom three-quarters were aged 50 or over. Of men between the ages of 18 and 50, 109,408 had been on the registers for under two weeks, 23,524 for from two weeks to four weeks, 17,715 for from four weeks to six weeks, 40,554 for from six weeks to 12 months, and 13,256 for 12 months or more. Of men between the ages of 50 and 65, 44,592 had been on the registers for under two weeks, 13,554 for from two weeks to four weeks, 10,920 for from four weeks to six weeks, 44,884 for from six weeks to 12 months, and 40,823 for 12 months or more. Of women between the ages of 18 and 60, 87,213 had been on the registers for under two weeks, 30,819 for from two weeks to four weeks, 28,513 for from four weeks to six weeks, 97,068 from from six weeks to 12 months, and 13,702 for 12 months or more.

In November, the home-branch membership of the Amalgamated Engineering Union increased from 445,214 to 454,669, and the Colonial-branch membership from 39,758 to 40,340. The number of members in receipt of sick benefit increased from 4,314 to 4,576, and the number in receipt of superannuation benefit from 13,423 to 13,474. The number in receipt of donation benefit increased from 470 to 490, and the total number of unemployed members decreased from 2,352 to 2,349.

In his report of the executive's proceedings in November, published in the December issue of the Amalgamated Engineering Union's *Journal*, Mr. Tanner, the president, mentions that after giving "consideration to the position arising from the employers' refusal" to concede the increase of wages claimed, the council "decided to recall the National Committee and to recommend that body to agree to the claim being submitted to arbitration." The resolution adopted by the recalled National Committee at Southport was as follows:—"That without prejudice to any future claims, or the union's freedom of action in future, this National Committee instructs the Executive Council to make an immediate application for an Arbitration Court to consider our wages application."

"We do not," the writer of the editorial notes in the same issue of the *Journal*, says, "propose to argue the merits of our claim. More important in the circumstances . . . is the reason given by the Engineering and Allied Employers' National Federation for the rejection of the union claim. In substance, the attitude of the employers has been that it is not in the national interest, or in accord with national policy, that wages should be raised. Admittedly, on the basis adopted by their own spokesman (Sir Alexander Ramsay), the Engineering Employers' Federation do not control the practical application of a general national wage policy. . . . But Sir Alexander went on to say that anything done in the engineering industry must have a profound effect on such policy. He claimed, too, that the employers had the responsibility of thinking ahead to the time when we must rehabilitate the industry on normal economic lines. . . . ."

"It was essentially on this ground," the writer continues, "and on these reasons that the Employers' Federation rejected our claim. It amounts to an assertion of responsibility by the employers for the determination of a general national wage policy. It takes no account of the fact that a general national wage policy has not been prescribed by the authority of the Government; nor has such a policy been considered by industry, though an attempt was made soon after the war began by the Joint Consultative Committee representing the T.U.C. General Council and the British Employers' Confederation to formulate the principles which could be applied to the regulation of wages in war time. What that representative and responsible body was unable to do is not, in our view, a question that the Engineering Employers' Federation is competent to decide on its own responsibility."

"As a union," the contributor of the editorial note goes on to say, "we take the view that until the principles of a general wage policy have been laid down in full consultation with the representatives of the trade unions, and in agreement with them, the employers in our industry have no right to determine the wage questions of the industry by reference to what they think ought to be the method of regulating wages in war time. They cannot escape discussion of related questions. Profits made in the engineering industry under war conditions, as in every other war industry, must be brought into the reckoning. So must the movement of prices. So, too, must the practice of accumulating large masses of undistributive profits as reserves."

In the course of a speech at the anniversary luncheon last week of the Printers' Pension, Almshouse, and Orphan Asylums Corporation, Mr. Bevin, the Minister of Labour and National Service, said that under the British system of production the individual output of the workers was greater than it was under the German system, which was based on compulsion. In this country, millions of hours, and property representing millions of pounds, had been saved by the introduction of the "spotter" system. Germany had not been able to do that. He had been told that he ought to introduce compulsion. "When you have compulsion," he declared, "you have to have selection. When you undertake the task of selection, clever as you are, you are apt to select the wrong people as against the volunteers."

A delegate conference of the South Wales Miners Federation which took place at Cardiff on December 7, adopted a resolution protesting against the new Order of the Minister of Labour and National Service for the recruitment of colliery workers to the armed Forces, on the ground that it discriminated against the use of the man-power of the coalfield because of a depression "which ought never to have been allowed to come about and which ought to be immediately remedied." The demand was re-affirmed that any raising of the age of reservation for the various categories of workmen should be applied equally to the man-power of the whole industry. The new Order raises the age of reservation for underground workers to 30, and tribunals are to ascertain how many men, under that age, can be spared for military service, having regard to the present and prospective man-power requirements in each mining area. Workmen under 30 who have been unemployed for six weeks lose their reservation and are liable to be called up for service. To that provision the conference objected strongly.

It was stated during the discussion that thousands of colliery workers in South Wales were unemployed because of the loss of the export trade and the failure to provide facilities for the transport of coal to inland markets. Under the new Order, it was added, practically all men under 30 would lose their reservation, while in coalfields more favourably placed, they would remain in employment. The view of the conference was that an equal proportion of colliery workers should be taken from each coalfield. The Government were called upon to provide such facilities as would enable the sales of South Wales coal to be increased abroad and at home. An immediate investigation by a body with authority to act and bring about an early improvement was demanded.

In its report for 1939, the Industrial Section of Shanghai Municipal Council states that average hours of work for all industries amounted to 10·92 in the day, being slightly less than in the previous year. The highest average was in silk reeling (11·67). Textile industries in general exceeded the average, owing to an increase in activity in these branches. Tobacco factories, on the other hand, worked on an average only 6·9 hours a day, owing to declining business. The number of working days per month increased, an average of 23·78 days being worked per month in 1939 as compared with 22·48 in 1938 and 23·66 in 1936. The paper industry ranked highest in the number of working days with 28·59 days to the month, oil coming next with 27·81 days and flour third with 27·22 days. In the match industry, the average was only 15·36 days and in silk weaving 19·23 days; this was due in part to shortage of raw materials.

PREHISTORIC AND PRIMITIVE IRON SMELTING.*

By E. WYNDHAM HULME, B.A.

PART 2: THE CRUCIBLE PROCESSES OF THE EAST.

THE discovery that fine gold could be made available for working by melting in crucibles with forced draught was an invention of the Third Millennium B.C., the importance of which in the development of civilisation has been somewhat overlooked. The Golden Age, which it ushered in, is represented in archæology by the Bronze Age, with which it is roughly contemporary. The Silver Age, which followed it, is the Age of the Hittites, *i.e.*, the silver men, the economic basis of whose empire was the wealth of the silver mines of Cilicia.

The dissolution of the Hittite Empire, c. 1200 B.C., marks the introduction of the Iron age, *i.e.*, the age characterised by the use of iron on an industrial scale, which, in a previous paper, I traced to the development of iron making in N.W. Persia. It is interesting to note that, in the Ancient East, peoples reputed for their metallurgical knowledge (for example, the Sumerians, Chalybians, Dactyli or Telchinians) possessed either traditions of a marine origin or are known as mariners. These traditions are indicative of folk movements, mainly from the East, passing through Persia and Asia Minor to the Ægean, Crete and Macedonia. These incidental remarks serve as a background to the study of the crucible processes of the East, the distribution of which suggests an intercourse between races widely separated in space. These processes I propose to take in the following order, viz.:—(1) China; (2) India; (3) Ceylon; (4) Japan.

China: Shansi Province.—In 1910, Professor T. T. Read, of Columbia University, visited China, and in conjunction with two Chinese metallurgists studied the metallurgical processes in use at the Pingtinchow Ironworks in that province. My account is based upon an article in ENGINEERING in December, 1910,† probably contributed by Professor Read, and on later papers by him in 1924 and 1934.‡ This Shansi process is substantially unique, as it utilises the crucible both for smelting and conversion purposes.

The furnace dimensions are 12 ft. by 6 ft., with walls 4 ft. high, and the fuel is anthracite. The interior is packed with 4-ft. clay cylinders 5 in. in diameter, set vertically in batches of from 250 to 275 at a time. The cylinders are filled with iron ore and anthracite in about equal proportions. Smelting with natural draught occupies from 3 to 4 days. When completed, the bottoms of the cylinders are broken to extract the bloom, which is treated for conversion into malleable iron. Near the upper end of the cylinders the iron varies from nut to small-shot size, and this iron is preferred for conversion into cast iron. The smaller pieces of iron are transferred to dwarf crucibles, the dimensions of which are variously stated (7 in. by 14 in. diameter and 12 in. by 10 in. diameter). Probably the size varies with the foundry requirements, *i.e.*, for large castings a larger size of crucible is needed. The crucibles are filled with iron and anthracite in batches of 70 to 80 at a time and are fired with anthracite and forced draught. Cast iron is produced at the end of the operation, which probably lasts 3 to 4 hours.

Read stated that in current practice a weathered coal, called Hei-Tu, containing phosphorus, is introduced into the crucibles whereby a material reduction of the temperature for fusing the metal is effected; but his analyses of early Chinese castings disprove his suggestion that this economy facilitated the coming of cast iron.§ An analysis of Hei-Tu is given in the *Beitrage zur Geschichte der Technik*, vol. 21, page 153.

China: Hankow District.—Here malleable iron is produced in crucibles, in batches of 60 at a time, containing 4 parts of ore (magnesite) to 2 parts of small coal. Smelting with forced draught results, at the end of 16 hours, in the production of white cast iron, which breaks up into a brittle dust, and pieces of softer iron. The latter are refined in a wood fire.

India.—The principal seat in the past of the Indian cast-steel process was in what is now the Nizam's Territory, or the State of Haiderabad. An obscure description of this process is contained in the abridgment of the Indika of Ktesias. The original, which is lost, was composed about 400 B.C., but an abridgment by Photius has survived. It was made some 1,200 years after the date of the original. The following

* Paper presented at a meeting of the Newcomen Society, held at the Iron and Steel Institute, London, on Wednesday, November 13, 1940. Abridged. Part I appeared in ENGINEERING, vol. 146, page 632 (1938).

† ENGINEERING, vol. 90, page 761 (1910).

‡ *Iron Age*, vol. 108, page 451 (1921); and "The Early Casting of Iron in China," by T. T. Read, *Geographical Review*, October, 1934.

§ T. T. Read, *ibid.*

PRIMITIVE IRON SMELTING.

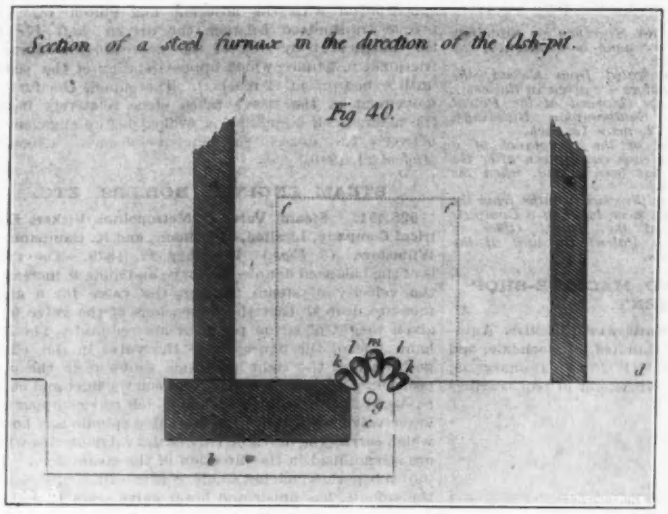


FIG. 1.

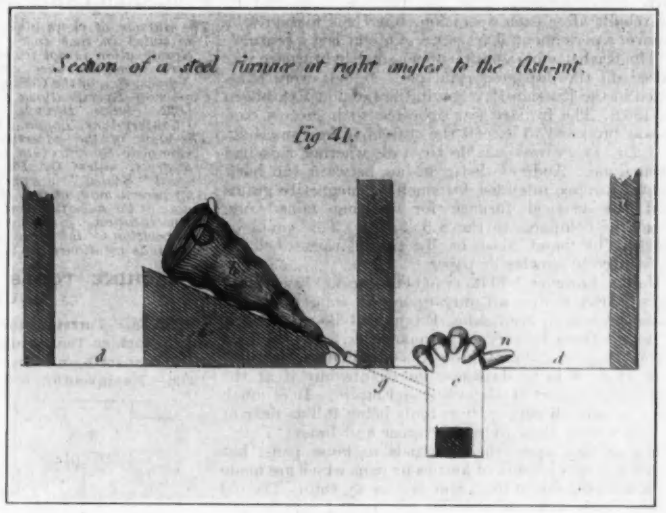


FIG. 2.

translation has been made from the text of the Göttingen edition of 1823.

"Concerning the Spring which is filled every year with alluvial gold, from which 100 earthen pitchers are drawn up annually. The pitchers must be earthen since the gold when withdrawn is in a solid state, and it is necessary to break them to extract it. The Spring is of a square shape with a perimeter of 16 cubits (24 ft.) and a fathom (6 ft.) in depth. Each pitcher weighs a talent (0·57 lb.).

"And concerning the iron found at the bottom of the Spring, Ktesias says that from it he had in his possession two swords, one a gift from the King, and the other from the King's mother, Parysatis. He says of this iron that, if fixed in the ground, it wards off clouds and hail and thunderstorms. This, he says, he witnessed himself, the King officiating on both occasions."

Commentors on the Indika, including Dr. Beck, the metallurgist, have suggested that the so-called Spring of Ktesias must from its dimensions be regarded as a smelting furnace rather than a cistern or tank,* and now, using the account of the Shansi process as a guide, we may safely identify the pitchers as crucibles.† Their number, 100, against Shansi's 250-275, and weight, when filled with ore and fuel, are both reasonable, and the design and dimensions of the furnace correspond closely with what is known of the Persian model. My conclusion is that Ktesias entirely failed to grasp the basic principle of the process told him, but correctly recorded the dimensions. We are therefore concerned with the account revealed behind the text rather than with the text itself. The following amendments, however, seem necessary—in paragraph 1 to read "alluvial iron and gold" and in paragraph 2 "iron" instead of "gold." As applied to gold, the statements are meaningless; but apart from this the text itself requires these changes, for in the final portion of the narrative Ktesias most unaccountably switches over from gold to "the iron found at the bottom of the Spring," showing that he had really been dealing with iron throughout. Possibly his abridger, Photius, thought that gold made a better story of it.

We have no direct evidence as to the Haiderabad second operation or conversion process, but if it is legitimate to include the Chalybean process in the crucible class, because the steel was said to be indistinguishable from silver, the same reasoning would apply to the Haiderabad process, since the Indian steel was described by Quintus Curtius as "*Ferrum Indicum candidum.*"‡

Another account of the conversion process as practised in the Nizam's dominions occurs in the Voysey MSS.§ The operation was observed at Kona Samundor, 12 miles south of the Godaveri River and 25 miles from Nirmul. The furnace is a circular structure of clay, 4 ft. to 5 ft. high and 5 ft. in diameter, sunk 2 ft. below the surface of the ground. The iron is converted

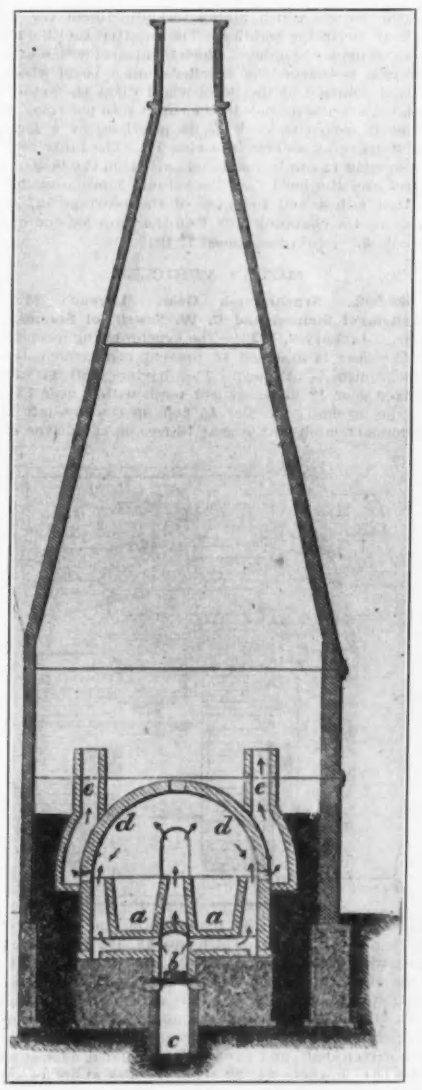


FIG. 3.

in pine-shaped crucibles, the size of which varies with the purpose for which the steel is intended. A granitic clay is used, mixed with ground crucible and kneaded with chaff of rice and oil. The tops of the crucibles are sealed. No charcoal is put in, but small pieces of glassy slag called *Kansh* are placed in their bottoms to serve as a flux. Two kinds of ore are used, magnetite and clay iron ore. The steel cake is covered with clay before annealing. The furnace temperature is given as c. 130 Wedgwood, which, according to figures kindly supplied by Dr. Goldsmith, might be as high as 1,400 deg. C.—a temperature seldom attained in the bloomery furnace.

If Voysey's account is correct, the Haiderabad process must have differed from those farther south, both as regards the size and construction of the furnace and the contents and disposition of the crucibles. Buchanan's account is known by the abridgment in Dr. Percy's *Iron and Steel** and was accompanied by the illustrations reproduced as Figs. 1 and 2. It will be seen that the above processes anticipate Huntsman in the ashpit sunk below the hearth, the manner in which the flame is brought to the crucibles and still more remarkably in the use of a flux (see Fig. 3). Huntsman at first used bottle glass, but abandoned it. Buchanan's account is corroborated by Heyne.† Wilkinson‡ said that the steel of the Carnatic was inferior to that of Haiderabad; but the Wootz steel industry was already on the down grade at the end of the Eighteenth Century when the subject of Indian steel first attracted the attention of the learned.

Ceylon follows generally the Indian practice. Chips of *Cassia auriculata* are filled with the iron into crucibles in proportion to 12¼ oz. of iron to 5 oz. of the wood. The crucibles are clay tubes 8 in. long, 2 in. in diameter and 14 in. thick. Blowing is stopped during the conversion operation to enable the crucibles to be turned round. The product is a rod of cast steel. Coomaraswamy's account,§ however, was based on a trial smelting arranged specially for the purpose of his 1904 report. At that date the industry was moribund. Hence the number of crucibles commonly used at a time is not stated.

Japan.—Japanese processes for steel making are not based upon the crucible principle. Gowland's account‖ is incomplete. A fuller and more accurate statement by R. S. Lyman will be found in the *Progress Reports of the Geological Survey of Japan*, 1878-79, pages 60 to 78. Andree's *Die Metalle bei den Naturvölkern* will also be found useful. The Japanese furnace is of a low horizontal section, forming a Vee-shaped trough pierced on both sides with tuyeres, and with a hole at each end of the trough for drawing off slag and pig iron. Owing to the high temperature generated by the blast, the furnace walls are rapidly corroded. During the first two days' blowing, some slag and pig iron run out. In course of the third day the blast is stopped, and the mass, consisting of good and bad steel and pig iron, is extracted. A feature of this process is that an increased demand can be met by the addition of fresh units, *i.e.*, by a horizontal extension of the system and this without loss of quality in the

* L. Beck, *Geschichte des Eisens*, vol. 1, page 229.

† Cf. "The Evidence for Ancient Mining," by C. E. N. Bromehead, *Geographical Journal*, *August*, 1940; and Fr. Buchanan, *A Journey from Madras*, vol. 2, page 20.

‡ Quintus Curtius, *History of Alexander the Great*, vol. 2, page 350.

§ Reproduced in the *Journal* of the Royal Asiatic Society, vol. 1 (1832).

* J. Percy, *Metallurgy: Iron and Steel*, page 773 (1866).

† B. Heyne, *Tracts on India*, xxiv, page 358 (1814).

‡ H. Wilkinson, *Engines of War*, page 201 (1841).

§ *Mineralogical Survey of Ceylon* (1904).

‖ "The Early Metallurgy of Copper," by W. Gowland, *Archæologia*, vol. 56, page 305 (1899).

product. In Europe, the reverse was the case. The vertical raising of the furnace walls was attended by a successive deterioration in the quality of the iron. Gowland's remarks on the Japanese system are singularly inappropriate. True the furnace walls had to be rebuilt after each operation, but their foundations were of a permanent character and might last a century.

The Rachette horizontal copper-smelting furnace was based on the Japanese principle. Models were exhibited in the Russian Pavilion in the London Exhibition of 1862. The furnace was operated with success, and it was proposed to extend the system to iron smelting, but Dr. Percy was unable to state whether this had been done. Andree* distinguishes between the horizontal furnace intended for smelting magnetite grains and the vertical furnace for treating mined ore, which he compares to the Stück-ofen. This could be worked by hand blast or by the platform bellows illustrated in Gowland's paper.

Japan, however, had its crucible process. Kaempfer† says "Iron is dug up only upon the confines of the three provinces, Mimasaka, Bitsju and Bisen. But it is found there in very large quantities. It is refined upon the spot, and cast into staffs or cylinders, two span long (1 ft. 6 in.). Japanese merchants buy it at the place and export it all over the Empire. It is much of a price with copper, iron tools being full as dear or rather dearer than those of copper and brass. . . . They do not dress their victuals in brass pans, but have a particular sort of kettles or pans which are made of a composition of iron, and are pretty thin. The old ones of this sort are very much esteemed, and bought at a great rate, they having somewhat particular in their shape and make, which at present they have lost the art to imitate." These thin cast-iron kettles or pans are probably the Chinese hollow ware described by T. T. Read,‡ which the Chinese regard as valueless.

Before quitting Japan, reference must be made to a passage in Mandelslo's *Travels* in that country in 1639, which runs as follows:—"They have, among others, a particular invention for the melting of iron, without the using the fire, casting it into a tun done about on the inside with about half a foot of earth, where they keep it (melting) with continual blowing, and take it out by ladles full, to give it what form they please, much better and more artificially than the inhabitants of Liége are able to do."

Whether or not this passage did, or as Dr. Percy thought, did not, constitute an anticipation in law of the Bessemer invention I do not propose to discuss. Since the publication of Dr. Percy's *Iron and Steel*, our knowledge of Far Eastern metallurgy has grown materially. The iron referred to was, no doubt, white or mottled pig, which contains sufficient combined carbon to generate the heat required to keep the metal molten. At what point in the converter the blast was introduced is not stated; but Gowland's figure§ of the Japanese moving platform blower shows that their apparatus was an efficient one. Hence it is clear that the principle of the Bessemer process was known in Japanese practice a couple of centuries before it was brought to fruition in this country.

This concludes my survey of the crucible processes of the East. From it the history of the iron manufacture may be outlined as follows:—Iron is first discovered in the bath of molten gold. Its identification with meteoric iron quickly follows and its source is traced to the black sand of the rivers and streams. The magnetite is now collected and the preference shown for this ore is maintained throughout the history of the Eastern iron industry. For converting iron into cast steel the crucible process was the only practicable one; but according to Ktesias, large crucibles were used for smelting the ore also. Obviously it would be dangerous to lean too heavily on Ktesias's account, but it is not incredible; for until the Indians had learned a way to reduce granular magnetite in the open hearth, crucible smelting, though uneconomic, may have prevailed. Its survival in Shansi is explained by the abundance of anthracite in that province.

The Wootz steel process differed from all others by two peculiarities: carbon was introduced into the crucibles in the form of the wood and leaves of specific plants, which were held to be indispensable to success; and Wootz steel was unique in its production of the Damascus pattern, which I have suggested, originated in a humble imitation of the crystalline (octohedral) structure of meteoric iron. Taken as a whole, the processes of the East may be described as more flexible than those of contemporary Europe. They were based on the control of a higher range of temperatures and denote a deeper insight into the principles of iron metallurgy.

* R. Andree, *Die Metalle bei den Naturvölkern*, page 113 (1884).

† E. Kaempfer, *History of Japan*, 1690-2, translated by J. G. Scheuchzer.

‡ "Primitive Iron Smelting in China," by T. T. Read, *Iron Age*, vol. 108, page 451 (1921).

§ *loc. cit.*

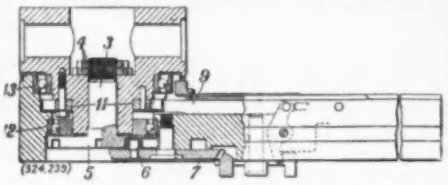
"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification drawings is stated in each case; where none is mentioned, the Specification is not illustrated.
Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

MACHINE TOOLS AND MACHINE-SHOP EQUIPMENT.

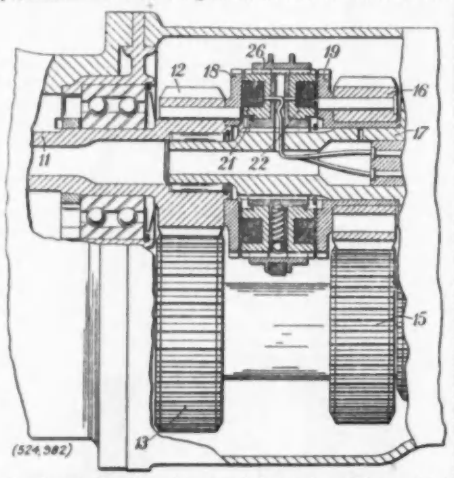
524,239. Turret Lathe. Butterworth British Automatic Machine Tool Company, Limited, of Rochdale, and H. Butterworth, of Rochdale. (1 *Fig.*) January 25, 1939.—The invention is an arrangement of ball bearings



for the turret, which allows for adjustment for wear without sacrificing rigidity. The rotating tool holder is clamped upon a spindle 3, which is integral with a cam 5. The cam is engaged by a roller 6 on a bevel wheel 7, so that rotation of the bevel wheel turns the spindle 3 to bring successive tools in the turret into position. The turret is locked in each of its positions by a locking bar 9 engaging sockets in a ring 11. The inner race of the bearing 12 can be displaced axially on the boss of the turret and the head 5 of the spindle 3 bears against it so that adjustment for wear of the bearings 12, 13 is made by the clamping nuts 4 on the threaded end of the spindle 3. (*Accepted August* 1, 1940.)

MOTOR VEHICLES.

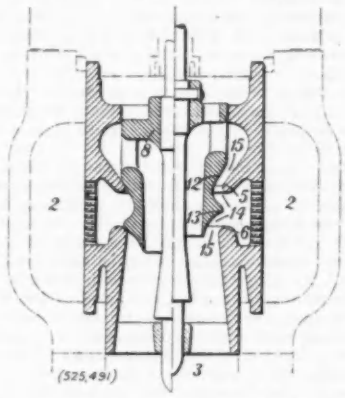
524,982. Synchromesh Gear. Lagonda Motors, Limited, of Staines, and C. W. Sewell, of Staines. (2 *Figs.*) January 9, 1939.—The synchronising mechanism of the gear is designed to prevent engagement before synchronism is attained. The driving shaft 11 carries a fixed gear 12 in permanent mesh with a gear 13 fast on the layshaft. A gear 15 fast on the layshaft is in permanent mesh with a gear 16 free on the driven shaft



17. A synchroniser is mounted on the driven shaft between two dog-clutch elements 18, 19, one of which is fast with the driving shaft and the other fast with the free gear 16 on the driven shaft. The synchroniser consists of a carrier and two movable electromagnets 21, 22 which coact with the adjacent flat faces of the dog-clutch elements. The carrier slides on splines on the driven shaft, and a central radial flange against which the two magnets 21, 22 seat, engages at its periphery with a sliding double-ended, dog-clutch sleeve 26, which, in its extreme positions, engages with one or other of the dog-clutch elements 18, 19. The sleeve also engages with the two magnets 21, 22. A spring-loaded ball centralises the carrier with respect to the sleeve. Current for the two coils is brought along leads inside the driven shaft. Starting from neutral, movement of the gear lever to introduce, say, top speed, operates a switch which closes the circuit for the respective magnet coil, and at the same time the sleeve and synchroniser are moved slightly as a unit to the left. The energisation of the coil tends to cause the magnet 21 to revolve in synchronism with the adjacent dog clutch 18. The torque transmitted between the driven shaft 17 and this magnet 21 by way of the sleeve 26 introduces a frictional resistance which opposes sliding of the sleeve until synchronism is reached. Thereupon, the further movement of the sleeve takes place relatively freely, the magnet-coil circuit being broken before engagement between the dog-clutch elements occurs. (*Accepted August* 20, 1940.)

STEAM ENGINES, BOILERS, ETC.

525,491. Steam Valve. Metropolitan-Vickers Electrical Company, Limited, of London, and K. Baumann, of Wilmslow. (3 *Figs.*) February 22, 1939.—The valve is of the balanced double-beat type and aims at increasing the velocity of steam through the valve for a given pressure drop so that the dimensions of the valve for a given weight of steam per hour are reduced. The left-hand side of the figure shows the valve in the closed position and the right-hand side shows it in the open position. Within the casing, between the inlet and outlet passages 2, 3, is secured a shell which carries upper and lower valve seats 5, 6. On the valve spindle is a boss 8 which carries the movable part of the valve on ribs which are streamlined in the direction of the steam flow. The movable part, which has a large central orifice surrounding the spindle, has upper and lower valve seats 12 and 13. The annular channels 14 on the inlet side of the valve seats are convergent while the channels 15 on the outlet side are divergent so that the steam attains its maximum velocity as it passes over the valve seats. The latter are ground so that their slant sides lie on lines which



converge to a common apex on the axis of the spindle. The valves are particularly suitable for use in a turbine-governing system in which the valves are oil-operated, since the reduction of the out-of-balance force enables smaller operating gear to be employed and a greater sensitivity obtained. (*Accepted August* 29, 1940.)

MISCELLANEOUS.

513,902. Plaster Board. Imperial Chemical Industries, Limited, of London, J. J. Etridge, of Norton-on-Tees, J. B. Sandford, of Saltburn, and V. Lefebure, of London. February 22, 1938.—The invention is a cement made from blast-furnace slag for use as a core material for plaster boards which does not suffer from the disadvantages of plaster of Paris, such as softness and low resistance to water. The new core mix is made up as follows:—Finely ground blast-furnace slag, 50 parts by weight; plaster of Paris, 50 parts by weight; and Portland cement, 3·2 parts by weight. Gum arabic is added in concentration of 0·3 to 1 per cent. to increase the initial adhesion, and ground gypsum is used as an accelerator. At least 60 per cent. of the mixed cement must be of diameter not exceeding 30 microns. The mix is gauged with 48 per cent. of water, giving an initial set of about 5 minutes and a firm set of about 10 minutes. A normal plaster board liner of high jute content, of thickness 0·03 in., is used. After forming and cutting, the board is dried at 78 deg. C. With such a board the adhesion, both dry and wet, is the maximum possible. Plaster boards made by this process can be dried at the temperatures used when the normal core of plaster of Paris is employed, in which case the strength is similar to that of normal dry plaster board. By drying at a lower temperature range of 50 deg. to 70 deg. C., however, stronger boards are obtained, chiefly because the normal hydration and strength development of the core is encouraged. The new boards have a high mechanical strength and resistance to water and atmospheric corrosion, and are suitable for external work. Actually, the strength of the core increases rather than decreases under constant wetting. The core is not markedly alkaline and has no harmful effect upon the fibre liner or on any decoration.—(*Accepted October* 25, 1939.)